ANXIETY SYMPTOMS AND THE PERCEPTION OF TIME: A CORRELATIONAL STUDY AMONG UNIVERSITY STUDENTS

[A sintomatologia ansiosa e a perceção do tempo: um estudo correlacional com estudantes universitários]

Dissertação de Mestrado

2.º Ciclo de estudos em Psicologia Clínica e da Saúde

Margarida Inês de Carvalho Pinto

Orientadoras:

Prof. Doutora Carina Fernandes

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Junho, 2026

UNIVERSIDADE FERNANDO PESSOA

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Acknowledgments

For as long as I can remember, I have strived for perfection. This dissertation put that quest to the test, challenging my perfectionism on countless occasions. As Steinbeck wrote, now that I don't have to be perfect, I can be good.

Although this dissertation bears my name on the cover, it is the result of the contributions, support, and dedication of many people, without whom I would not have been able to get this far.

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Abstract

The perception of time is a fundamental cognitive process that can be influenced by emotional states, such as anxiety, through changes in physiological arousal and the allocation of attentional resources. Although the literature suggests that anxiety may distort the experience of time, the results remain contradictory, particularly in non-clinical populations and across different time scales. This study aimed to explore the relationship between anxiety symptoms and time perception in college students, testing whether the effects varied across time intervals of different durations. A quantitative, correlational, and experimental design was used with 33 college students aged 18 to 23. Anxiety symptoms were assessed using the Generalized Anxiety Disorder-7 (GAD-7) questionnaire. Time perception was assessed using the Time Bisection Task, encompassing a short-duration condition (100–600 ms) and a long-duration condition (1000–3000 ms). The primary metrics included the Bisection Point as an indicator of temporal bias and the Weber Ratio as an indicator of sensitivity and temporal variability. No significant correlations were found between anxiety symptoms, the Bisection Point, and the Weber Ratio in any of the temporal conditions. The results suggest that, in a non-clinical university sample, subclinical anxiety symptoms do not appear to induce systematic distortions in time perception or sensitivity. However, the absence of statistically significant results may be explained by the small sample size, which may have limited the study's statistical power to detect more subtle associations or effects.

Keywords: *Anxiety symptomatology; Subjective time perception; Temporal bisection task; Bisection point; Weber ratio; University students*

Resumo

A perceção do tempo é um processo cognitivo fundamental que pode ser influenciado por estados emocionais, como a ansiedade, através de alterações na excitação fisiológica e na alocação de recursos atencionais. Embora a literatura sugira que a ansiedade pode distorcer a experiência temporal, os resultados permanecem contraditórios, particularmente em populações não clínicas e em diferentes escalas temporais. Este estudo teve como objetivo explorar a relação entre os sintomas de ansiedade e a perceção do tempo em estudantes universitários, testando se os efeitos variavam em função de intervalos de tempo com diferentes durações. Foi utilizado um desenho quantitativo, correlacional e experimental com 33 estudantes universitários com idades entre os 18 e os 23 anos. Os sintomas de ansiedade foram avaliados utilizando o Questionário de Ansiedade Generalizada-7 (GAD-7). A perceção do tempo foi avaliada através da tarefa de Bissecção Temporal, abrangendo uma condição de curta duração (100-600 ms) e outra de longa duração (1000-3000 ms). As métricas principais incluíram o Ponto de Bisseção como indicador de viés temporal e o Rácio de Weber como indicador de sensibilidade e variabilidade temporal. Não foram encontradas correlações significativas entre os sintomas de ansiedade, o Ponto de Bissecção e o Rácio de Weber em nenhuma das condições temporais. Os resultados sugerem que, numa amostra universitária não clínica, sintomas subclínicos de ansiedade não parecem induzir distorções sistemáticas na perceção ou sensibilidade ao tempo. No entanto, a ausência de resultados estatisticamente significativos pode ser explicada pelo tamanho reduzido da amostra, o que poderá ter limitado o poder estatístico do estudo para detetar associações ou efeitos mais subtis.

Palavras-Chave: *Sintomatologia ansiosa; Perceção subjetiva do tempo; Tarefa de bisseção temporal; Ponto de bisseção; Rácio de Weber; Estudantes universitários*

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List of Abbreviations, Acronyms, Symbols, or Initialisms

AGM - Attentional-Gate Model

BP - Bisection point

DL - Difference limen

GAD-7 - Generalized Anxiety Disorder-7

SET - Scalar Expectancy Theory

TL – Long reference duration

TS – Short reference duration

WR – Weber Ratio

1. Introduction

Time perception involves the mental processes by which people perceive, estimate, and interpret the passing of time (Mioni et al., 2020). It is a crucial function that supports many daily activities, such as motor coordination, speaking, and making decisions (Kondo et al., 2024). By helping people anticipate events, recognize patterns over time, and organize their behaviour, time perception is key to functioning effectively (Mioni et al., 2020). Recent studies suggest that time perception is a complex and flexible process involving several neural systems rather than just one internal mechanism (Allingham et al., 2021; Kondo et al., 2024; Mioni et al., 2020).

Time perception is not a single concept; it includes various ways of processing time (Block & Gruber, 2014). A major difference is between prospective and retrospective time perception. In prospective tasks, people know in advance that they will need to estimate time, which causes them to rely more on attention (Block & Gruber, 2014). In contrast, retrospective time perception happens when people are unaware that they will need to make a time judgment, depending more on memory to recreate temporal information (Block & Gruber, 2014; Droit-Volet & Meck, 2007).

These differences show that various cognitive processes are involved in making time judgments based on the task and surrounding circumstances. It is also important to differentiate time perception from related constructs like temporal orientation and time estimation. Temporal orientation is the ability to locate oneself within a time frame (for instance, past, present, future) and is often examined in clinical and neuropsychological studies (Caselli et al., 2009; Miyawaki, 2022). Time estimation specifically involves the ability to judge or reproduce lengths of time (Matthews & Meck, 2014). In contrast, time perception covers a wider range of processes related to encoding, processing, and experiencing time information (Mioni et al., 2020). Understanding this distinction is crucial because these concepts rely on overlapping but separate cognitive and neural mechanisms (Matthews & Meck, 2014; Mioni et al., 2020).

Moreover, time perception results from the interaction of various cognitive and emotional processes, including attention, memory, and feelings. Recent studies show that emotional and motivational elements can greatly influence how individuals perceive time, underscoring that time perception is affected by many factors and the context in which it occurs (Gable et al., 2022; Harana-Lahera, 2022; Lake et al., 2016).

The study of time perception has received more attention recently (Kondo et al., 2024; Mioni et al., 2020). Distortions in how people process time have been linked to cognitive function, emotional regulation, and behavior. Changes in how individuals experience time appear across various psychological conditions, suggesting that time perception might reflect underlying cognitive and emotional processes (Kondo et al., 2024; Mioni et al., 2020).

Evidence shows that emotional states, like anxiety, are important in shaping our experience of time (Gable et al., 2022; Sarigiannidis et al., 2020). Anxiety leads to increased physical arousal and attention biases toward threats (Gable et al., 2020). Both factors can affect our internal timing mechanisms (Sarigiannidis et al., 2020). These changes can result in consistent distortions in time perception, impacting how people experience and react to their surroundings.

Despite the growing interest, several gaps exist in the literature. First, research on the effects of anxiety on time perception is inconsistent. Some studies show that people with anxiety overestimate time (e,g,. Harjunen et al., 2021), while others find that they underestimate it (e.g., Sarigiannidis et al., 2020). These differences may come from variations in task requirements, especially the cognitive processes needed for timing tasks (Matthews & Meck, 2014). Second, few studies have looked at time perception across different time scales, such as short (sub-second intervals, typically defined as lasting less than one second), and long intervals (supra-second intervals, typically defined as lasting more than one second). These scales likely rely on partially different cognitive processes (Matthews & Meck, 2014). Additionally, most research has focused on clinical populations, including individuals diagnosed with anxiety disorders (e.g., Jusyte et al., 2015) and major depressive disorder (e.g., Liu et al., 2022). There is less understanding of how subclinical anxiety symptoms may affect time processing in non-clinical groups.

Therefore, this study aims to explore how anxiety symptoms affect subjective time perception in a non-clinical sample composed of university students. It specifically investigates whether anxiety is linked to systematic distortions in how people judge time and whether these effects vary between short and long time intervals. Using a temporal bisection task, this research seeks to enhance our understanding of the cognitive and emotional mechanisms related to time perception.

2. Theoretical Framework

2.1. Subjective Time Perception

Time perception is a complex concept that includes how people notice, measure, and understand time. As said before, recent studies view time perception as a changing process that relies on various thinking and brain systems instead of one internal mechanism (Allingham et al., 2021; Kondo et al., 2024). Knowing how these systems work together is important to explain the changes in the experience of time that individuals see during different emotions and mental states.

The term time perception refers to the processing and experience of temporal properties, including duration (the perceived length of an event or interval), simultaneity (whether two events occur at the same time), succession (whether events occur one after another) and temporal order (the sequence in which events occur) (Hoerl, 2026). As noted by Hoerl (2026), the concept of time perception includes various psychological phenomena and can be understood differently based on how researchers define “time” and “perception”, although it is often used to refer to the personal experience and estimation of duration. This study specifically focuses on subjective time perception, which involves estimating and evaluating temporal durations (Hoerl, 2026; Lake et al., 2016).

Time perception is inherently subjective and arises from the combination of several cognitive mechanisms, primarily attention, memory, and arousal (Harana-Lahera, 2022). Attention determines how much temporal information is noticed, while memory helps encode and compare durations (Harana-Lahera, 2022). At the same time, physiological arousal affects the speed of internal timing processes, leading to differences in how duration is perceived (Gable et al., 2022). These interacting mechanisms explain why the same objective time frame can feel different based on cognitive load, emotional state, or context (Gable et al., 2022; Harana-Lahera, 2022).

A key aspect of time perception is how it can be distorted, leading to temporal illusions (Harana-Lahera, 2022). These distortions usually appear as overestimation, where a duration feels longer than it is, or underestimation, where it feels shorter. Such biases are systematic and reflect changes in underlying cognitive and physiological processes (Gable et al., 2022). For example, higher arousal is often linked with overestimating time, while distractions or cognitive load typically result in underestimating duration (Gable et al., 2022; Harjunen et al., 2022; Sarigiannidis et al., 2020).

Emotional states and clinical conditions are significant factors that affect time perception (Harana-Lahera, 2022). Anxiety, in particular, is often linked to changes in attentional focus and physiological arousal, both critical to temporal processing (Sarigiannidis et al., 2020). Increased arousal might speed up internal timing mechanisms, while attentional shifts toward threats may limit cognitive resources for tracking time (Sarigiannidis et al., 2020). These processes can lead to varied patterns of temporal distortion depending on task requirements and context (Harana-Lahera, 2022; Sarigiannidis et al., 2020).

Overall, these findings support the idea that time perception is complex and affected by context, shaped by the interaction among cognitive, emotional, and neurobiological processes. Understanding these mechanisms is vital for interpreting the temporal distortions seen in both clinical and non-clinical groups.

2.2. Explanatory models of time perception

Several theories have been suggested to explain how people perceive and process time. These theories describe the mental and brain processes involved in estimating and distinguishing between time intervals (Matthews & Meck, 2014; Wiener et al., 2010).

One of the earliest formal explanations of temporal processing was put forward by Treisman (1963), who introduced the idea of an internal clock. According to this model, our perception of time depends on a pacemaker that sends out pulses at a steady rate, a switch that controls the flow of these pulses, and an accumulator that holds them. Temporal judgments are made by comparing the number of pulses collected with reference values stored in our memory. This model laid the groundwork for later theories about interval timing.

Building on this idea, Gibbon (1977) developed the Scalar Expectancy Theory (SET), which is one of the most important models in the study of time perception. SET includes the main parts of the internal clock model — pacemaker, switch, and accumulator — but adds the principle of scalar timing. This principle states that the variability in time estimation grows with the length of the interval. In this framework, perceived duration relies on the number of pulses gathered during a specific interval and their comparison with temporal representations stored in memory (Gibbon, 1977; Matthews & Meck, 2014).

These models suggest that changes in physiological arousal can affect the pacemaker's speed (Wiener et al., 2010). Higher arousal is thought to speed up pulse emissions, leading to a greater number of accumulated pulses and a perception of longer durations (Gable et al., 2022; Wiener et al., 2010). On the other hand, lower arousal may slow the pacemaker, resulting in shorter perceived durations (Wiener et al., 2010). These mechanisms offer a theoretical understanding of the systematic errors in time perception during different cognitive and emotional states (Gable et al., 2022).

Expanding on internal-clock ideas, Zakay and Block (1995) introduced the Attentional-Gate Model (AGM), which highlights the role of attention in how time is perceived. According to this model, judgements of time depend not only on the pacemaker-accumulator system but also on an attentional gate that controls the flow of pulses reaching the accumulator (Matthews & Meck, 2014). When attention is focused on time, the gate stays open, allowing more pulses to reach the accumulator, which makes durations seem longer. On the other hand, when our attention shifts to non-temporal parts of a task or outside events, the gate partially closes. This leads to fewer accumulated pulses and shorter perceived durations (Block & Gruber, 2014; Zakay & Block, 1995). This mechanism helps explain why time may feel like it stretches when we concentrate on temporal information and contracts when we face increased cognitive load or distractions (Block & Gruber, 2014).

Although these models have greatly helped us understand how time is processed, each has its drawbacks. The Internal Clock Model provides a straightforward and influential explanation of interval timing (Treisman, 1963). However, it only offers a limited view of how contextual, emotional, and attention factors affect our perception of time (Matthews & Meck, 2014). Scalar Expectancy Theory builds on this idea by including memory processes and explaining the differences in time judgments for various lengths of time (Gibbon, 1977; Matthews & Meck, 2014). Still, it mainly focuses on estimating durations.

In contrast, the Attentional-Gate Model recognizes that our time judgments are affected not just by our internal timing functions, but also by how we allocate our attention (Zakay & Block, 1995; Matthews & Meck, 2014). This is a significant step forward, as our perception of time does not happen separately from other cognitive and emotional processes (Block & Gruber, 2014; Gable et al., 2022). However, the AGM has faced criticism for oversimplifying the link between attention and the experience of time and for not fully addressing the complex ways emotions impact timing (Matthews & Meck, 2014).

Despite these limitations, the AGM is particularly relevant to the current study. Anxiety is connected with changes in attention (Sarigiannidis et al., 2020) and the allocation of cognitive resources (Harana-Lahera, 2022). This model offers a helpful framework for understanding how anxiety symptoms might lead to distortions in the perception of duration (Zakay & Block, 1995; Block & Gruber, 2014). Therefore, while this study recognizes the importance of all three models, it mainly relies on the ideas put forth by the Attentional-Gate Model.

2.3. Cognitive and neurobiological processes

Time perception is supported by a range of cognitive and neurobiological processes that contribute to the encoding, storage, and evaluation of temporal information. Studies show that different durations depend on somewhat distinct processes. A well-known distinction separates sub-second intervals, which are typically less than one second, from supra-second intervals, which are longer than one second. Sub-second timing is mainly linked to automatic and sensory processes, while supra-second timing relies more on higher-level thinking, especially attention and working memory (Lake et al., 2016; Matthews & Meck, 2014; Mioni et al., 2020). This suggests that different cognitive systems are active depending on the duration being measured.

In this context, shorter intervals (sub-second) often depend mainly on automatic timing methods. Longer intervals (supra-seconds), however, require more controlled cognitive effort. As a result, issues with attention or working memory are more likely to affect judgments related to longer durations (Matthews & Meck, 2014; Mioni et al., 2020). On the other hand, changes in physiological arousal may have a bigger effect on shorter intervals by altering the speed of internal timing mechanisms (Gable et al., 2022; Matthews & Meck, 2014).

At the neurobiological level, dopamine systems are critical for processing time. Dopamine affects activity in cortico-striatal circuits, particularly in the basal ganglia, which are essential for internal timing mechanisms (Matell & Meck, 2004; Meck, 1996). Changes in dopamine levels have been linked to variations in the speed of the internal pacemaker. Higher dopamine levels are believed to speed up pacemaker activity, leading to overestimations of time (Matell & Meck, 2004; Meck, 1996). In contrast, lower dopamine levels can slow it down, resulting in underestimations of duration (Lake et al., 2016; Miyawaki, 2022).

These neurobiological processes align with internal clock models, especially SET. This theory suggests that perceived duration relies on the number of pulses gathered and compared with stored representations of time (Gibbon, 1977; Matthews & Meck, 2014). Within this framework, changes in neurochemistry and physiology can directly affect pacemaker speed, causing systematic distortions in how time is perceived.

Besides internal clock mechanisms, attention also plays a vital role in time judgments. The AGM (Zakay & Block, 1995) argues that how attention is directed affects how many temporal pulses are processed. When there is focus on time, more pulses pass through the attention gate, leading to longer perceived durations. On the flip side, if the attention shifts to non-temporal information, fewer pulses are accumulated, resulting in shorter perceived durations (Block & Gruber, 2014). Overall, these findings show that time perception is shaped by both automatic and controlled processes, along with underlying neurobiological systems. This integrated viewpoint is important for understanding how contextual, cognitive, and emotional factors, can create systematic distortions in our experience of time.

Evidence from theoretical and empirical research in internal-clock models suggests that both pacemaker speed and attention affect variability in time judgments (Allman et al., 2014; Matthews & Meck, 2014; Wiener et al., 2010). Specifically, these models argue that differences in perceived durations can result from changes in pulse generation and the way attention is allocated. These factors together influence how temporal information is encoded and compared with stored memories (Matthews & Meck, 2014; Zakay & Block, 1995). This view emphasizes the importance of looking at different mechanisms when studying individual differences in time perception.

2.4. Experimental approaches to the study of temporal perception

Experimental research on time perception has involved various behavioral tasks, each capturing distinct cognitive mechanisms underlying temporal processing. A fundamental distinction in time perception research concerns the difference between prospective and retrospective timing paradigms. In prospective timing, individuals are aware in advance that they will be required to make a temporal judgment, which leads to increased allocation of attentional resources toward time (Block & Gruber, 2014; Wearden, 2016). As a result, perceived duration is strongly influenced by the amount of attention dedicated to temporal processing (Block & Gruber, 2014). In contrast, retrospective timing occurs when individuals are not informed beforehand that they will be asked to judge duration (Block & Gruber, 2014; Wearden, 2016). Under these conditions, temporal judgments rely primarily on memory processes, particularly on the amount and complexity of information encoded during the interval (Block & Gruber, 2014; Wearden, 2016).

This distinction has important methodological implications, as prospective paradigms are more sensitive to attentional manipulations (Block & Gruber, 2014.) In contrast, retrospective paradigms are more influenced by memory-related factors (Block & Gruber, 2014; Wearden, 2016). Consequently, the same temporal interval may be perceived differently depending on the paradigm employed, which contributes to variability in findings across studies (Block & Gruber, 2014).

Within both prospective and retrospective paradigms, several experimental tasks have been developed to assess subjective duration, each engaging distinct cognitive processes.

In verbal estimation tasks, participants assign a numerical value to the perceived duration of a stimulus, requiring explicit temporal representation and the involvement of linguistic and memory processes (Ogden et al., 2021). In time production tasks, individuals are asked to generate a specified duration, relying on internal timing mechanisms and motor execution (Pednekar et al., 2024). Time reproduction tasks involve encoding a temporal interval and subsequently reproducing it, placing greater demands on working memory and sustained attention (Boned & López-Moliner, 2024).

Temporal discrimination tasks differ from these approaches in that they do not require explicit estimation or generation of time (Kopec & Brody, 2010). Instead, they involve comparing durations (Kopec & Brody, 2010). A widely used example is the temporal bisection task, in which participants first learn two reference durations (a short and a long interval) and are then asked to classify new stimuli as closer to one or the other (Kopec & Brody, 2010). This paradigm allows researchers to assess subjective timing through relative judgments, minimizing the influence of language and motor processes while emphasizing perceptual and decision-making components (Cropper et al., 2024; Kopec & Brody, 2010).

Therefore, the choice of task is crucial in determining which parts of the timing system are being evaluated (Droit-Volet & Meck, 2007).

Notably, evidence shows that temporal judgments differ across various time scales. Matthews and Meck (2014) argue that performance in timing tasks depends not only on the task structure but also on the range of durations measured. Short (sub-second) and long (supra-second) intervals may engage somewhat distinct cognitive processes, suggesting that differences in performance across temporal ranges should not be viewed as extensions of a single underlying mechanism. Short temporal intervals are more influenced by automatic attention capture and arousal-related processes, whereas longer intervals demand more sustained attention, working memory, and executive control. As the duration of intervals increases, participants must actively maintain temporal information and manage distractions, which heightens the role of higher-order cognitive processes in temporal judgments (Matthews & Meck, 2014).

A major contribution of Treisman (1963) further supports this distinction, demonstrating that short durations are often overestimated, whereas long durations tend to be underestimated, with a transition point, the indifference interval, typically around one second. These findings suggest that internal timing mechanisms do not operate uniformly across time scales and reinforce the importance of examining short and long intervals separately.

From a methodological standpoint, these considerations emphasize the need for time-based tasks that respond to changes in internal timing while reducing the effects of attention, language, and motor actions. Discrimination-based methods are particularly useful when the research aim is to isolate distortions in how time is perceived due to emotional or psychological factors rather than cognitive load (Droit-Volet & Meck, 2007). Among these methods, the temporal bisection task has been especially valuable for both basic and clinical research.

As described above, in the temporal bisection task, participants compare probe stimuli with intermediate durations to two reference durations, one "short" (TS) and one "long" (TL), which have been learned and stored in memory. The stimuli are generally tones or lights presented over varying intervals. During the learning stage, participants repeatedly see the reference durations. In the test stage, probe durations are introduced, and participants must decide if the probe is closer to TS or TL, providing a binary judgment ("short" vs. "long"). As this judgment is based on personal categorization rather than a correct answer, feedback is typically not given (Kopec & Brody, 2010).

This method is considered a reliable tool for assessing time perception since it involves several time-related cognitive tasks: encoding and remembering the short and long reference durations, measuring the probe duration, retrieving the reference durations from memory, and then comparing the probe to these values before making a decision (Kopec & Brody, 2010). From the responses, researchers create a psychometric function that maps stimulus duration to the probability of responding "long" (Kopec & Brody, 2010).

The point at which participants are equally likely to respond "short" or "long" is the Bisection Point (BP), or the time interval corresponding to 50% (Kopec & Brody, 2010; Liu et al., 2022). This measure indicates the subjective midpoint between TS and TL and provides insight into how durations are stored in memory and evaluated in decision-making (Kopec & Brody, 2010). When the psychophysical curve shifts toward longer durations, it indicates that participants need a longer interval to perceive it as "long," suggesting they underestimated how time passed (Sarigiannidis et al., 2020). Conversely, a shift toward shorter durations suggests that time passed more quickly (overestimation) (Sarigiannidis et al., 2020).

Additionally, the Weber Ratio (WR), defined as the just noticeable difference (difference limen, DL) divided by the BP, serves as a standardized index of temporal sensitivity adjusted for the estimated duration (Kopec & Brody, 2010; Sarigiannidis et al., 2020). A low WR means steep psychometric curves and high discriminability, while a high WR suggests shallow curves and less sensitivity (Sarigiannidis et al., 2020). Other metrics include the long response ratio and DL, which together assess the accuracy and precision of temporal judgments (Liu et al., 2022; Sarigiannidis et al., 2020).

Differences in the Bisection Point (BP) or Weber Ratio (WR) for short- and long-duration tasks may suggest that these time intervals depend on somewhat different cognitive mechanisms. Shorter intervals seem to rely more on automatic and perceptual timing processes. In contrast, longer intervals require more attention, working memory, and executive control (Block & Gruber, 2014; Matthews & Meck, 2014). As a result, changes in BP and WR across different time ranges may offer useful insights into the cognitive processes related to duration judgments.

Treisman's findings regarding the indifference interval are particularly relevant to the temporal bisection task, in which the bisection point indicates the duration judged equally likely to be "short" or "long" (Treisman, 1963). These results indicate that the placement of this point is not random but represents systematic perceptual biases influenced by interval length (Treisman, 1963). Intervals shorter than the indifference interval tend to be judged as longer, whereas those longer than it are viewed as shorter. Therefore, the BP serves not only as a behavioral index of temporal discrimination but also as an indirect measure of distortions from the pacemaker's speed, attentional allocation, or memory representation (Treisman, 1963). These principles support interpreting BP shifts in clinical groups, like those with anxiety, as potential indicators of altered internal-clock functions (Treisman, 1963).

Another important contribution to modeling performance in this task is the Two-Step Decision Model proposed by Kopec and Brody (2010). This computational framework assumes that reference durations are stored as noisy Gaussian distributions closer (Kopec & Brody, 2010). In the first step, the model checks if a probe duration matches one of the reference values closer (Kopec & Brody, 2010). If it does, the model provides the correct categorical response. If the probe is not close enough to either reference, the process moves to the second step. In this step, the probe is compared to both reference memories, and the response is determined by which one is closer (Kopec & Brody, 2010).

Decisions are influenced by sequential biases that align with the "gambler's fallacy." After producing many "long" responses, participants are more likely to respond "short," and the opposite occurs until balance is reached. This model shows that bisection judgments are affected by memory noise and by changes in decision-making throughout trials. The temporal bisection task is both simple and powerful. It produces several quantitative measures (BP, WR, DL, long response ratio) while enabling computational modeling of the underlying decision processes. These features make it especially useful for discovering subtle cognitive distortions (Liu et al., 2022).

Beyond providing behavioral indices such as BP and WR, the temporal bisection task is useful because it engages the perceptual, memory, and decision-making processes involved in making time judgments (Kopec & Brody, 2010).

A common limitation in many timing studies concerns the lack of control over participants' use of counting strategies, which introduces motor-related confounds and undermines the validity of results. In contrast, discrimination-based methods minimize this issue by requiring comparative judgments rather than overt time generation (Liu et al., 2022).

A key implication of the AGM is that different timing tasks demand varying levels of attentional engagement. Tasks involving time production and reproduction require continuous monitoring of temporal information and are therefore highly sensitive to attentional fluctuations. In contrast, discrimination-based paradigms such as temporal bisection rely more on comparisons between stored durations and are less dependent on sustained attention. Consequently, performance across timing tasks is not interchangeable, as observed distortions may reflect task-specific cognitive demands rather than uniform changes in internal timing mechanisms (Zakay & Block, 1995).

Emotional influences on time perception have frequently been investigated using adaptations of the temporal bisection task. In these paradigms, emotional stimuli (e.g., fearful or angry faces) are typically presented as probe stimuli during the test phase, and participants are instructed to judge whether their duration is closer to previously learned short or long reference intervals. These manipulations allow researchers to examine how emotional content affects perceived duration while maintaining the same temporal structure of the task. Findings consistently show that emotionally arousing stimuli are judged as lasting longer than neutral stimuli, supporting the idea that increased arousal speeds up internal timing mechanisms (Droit-Volet & Gil, 2009).

Research using temporal bisection tasks suggests that studying a single temporal range may obscure important differences in underlying timing mechanisms (Matthews & Meck, 2014). Distinguishing between short- and long-interval bisection tasks allows for a more precise analysis of timing performance, as variability and uncertainty tend to increase with interval duration (Caselli et al., 2009). This difference provides a methodological benefit, as it helps separate automatic timing processes from those needing focused attention and working memory (Caselli et al., 2009). Within the temporal bisection framework, this distinction is especially important.

Any factor that changes the pacemaker rate, attentional gate, or memory store, such as increased arousal, cognitive load, or emotional disturbances, may disproportionately influence performance for specific interval ranges. Therefore, distinguishing between short and long intervals can help identify subtle changes in internal-clock functioning associated with psychopathological symptoms (Treisman, 1963).

Systematic increases in temporal variability also characterize performance in the temporal bisection task as interval duration increases. Caselli et al. (2009) found that longer intervals are linked to wider response distributions, which aligns with a generalized form of Weber's law. This rise in variability highlights internal noise in the timing system and has direct implications for measures such as the WR, which gauges temporal sensitivity. Hence, changes in variability between short and long intervals may offer valuable insights into subtle shifts in cognitive functioning.

Matthews and Meck (2014) point out that bisection performance reveals how internal timing mechanisms and decision processes interact, and that both may be affected differently depending on the task's time scale. Thus, using separate bisection tasks for short and long duration ranges allows for a more detailed study of how our perception of time functions under different cognitive demands. Caselli et al. (2009) found that even when the ratio of short to long reference durations remains constant, performance differs consistently across tasks involving short and long intervals. Longer intervals tend to show greater variability and lower precision, indicating a greater reliance on attention and memory processes. In contrast, shorter intervals are more reliant on automatic timing mechanisms. These results support the idea that distinct cognitive resources are involved in judging time based on interval length (Caselli et al., 2009). Overall, these findings emphasize the importance of choosing time-based tasks that consider different cognitive aspects of timing when exploring psychological issues.

These findings suggest that performance in temporal bisection tasks is influenced by both the structure of the task and the duration range being measured (Matthews & Meck, 2014). Evidence shows that short and long intervals rely on partly different cognitive processes, shorter durations are more connected to automatic and perceptual mechanisms, while longer durations require more attention, working memory, and executive control (Caselli et al., 2009; Matthews & Meck, 2014). Therefore, comparing performance across different time ranges may lead to a better understanding of the mechanisms behind subjective time perception (Caselli et al., 2009). This difference is especially important when looking at individual variations, as changes in attention, working memory, or internal timing processes may impact short and long intervals in distinct ways (Matthews & Meck, 2014).

As a result, attention distortions (like those linked to emotional or psychological states) are likely to influence longer durations more significantly. The distinction between the cognitive processes used in short and long timing intervals gives a clear reason to study these periods separately. Short intervals seem to depend more on automatic and perceptual processes. In contrast, longer intervals require more attention, working memory, and executive control (Caselli et al., 2009; Matthews & Meck, 2014). As a result, analyzing short and long bisection tasks separately may show different aspects of time processing. This can help pinpoint the specific mechanisms behind the performance differences seen (Zakay & Block, 1995).

Examining short and long-duration intervals separately offers a strong reason to explore whether timing distortions mainly come from changes in basic timing processes, attention, or cognitive control. Differences in performance across temporal ranges may help pinpoint the specific mechanisms behind the observed distortions in subjective time perception (Caselli et al., 2009; Matthews & Meck, 2014). Additionally, several researchers have pointed out that the temporal bisection task works well for populations with limited cognitive resources. It minimizes the impact of working memory demands, language skills, and strategic counting (Aktaş & Gökçay, 2019).

Shorter durations are more closely linked to automatic, perceptual, and arousal-driven processes. Longer durations, however, require more focus, working memory, and executive control (Caselli et al., 2009; Matthews & Meck, 2014). As the interval duration increases, temporal judgments become more variable and less precise. This trend reflects higher cognitive demands and more noise within the timing system. These differences suggest that temporal perception can't be explained by a single, uniform mechanism. Instead, it involves multiple processes that change depending on the temporal scale.

From a research standpoint, these findings are important. Looking at only one time range may hide significant differences in the timing processes and lead to inconsistent results across studies (Caselli et al., 2009; Matthews & Meck, 2014). On the other hand, distinguishing between short and long interval bisection tasks allows for a clearer understanding of temporal performance (Caselli et al., 2009). It helps separate distortions from automatic timing processes and those caused by attention and higher-level cognitive demands (Block & Gruber, 2014; Matthews & Meck, 2014). This distinction is particularly important regarding psychological factors, such as anxiety, which can affect attention and cognitive control (Sarigiannidis et al., 2020; Harana-Lahera, 2022).

Therefore, including both short and long time intervals offers a more thorough and theoretically sound way to study time perception and its changes in clinical groups (Caselli et al., 2009; Matthews & Meck, 2014).

Kopec and Brody (2010) also stress the importance of training participants to correctly learn the reference durations and of randomizing the trial order to minimize bias and memory effects during the task. There is an increase in temporal variability as durations lengthen, which is consistent with a broader version of Weber's law. This means that discrimination becomes less precise over longer intervals, a trend reliably observed across various tasks and sensory modalities. This variability is not just a psychological effect; it reflects significant noise within the timing system. This is particularly relevant in psychopathological research, as alterations in internal timing mechanisms, attentional control, and cognitive processing (commonly observed in conditions such as anxiety and depression) may exacerbate this variability and lead to systematic distortions in temporal judgments (Kopec & Brody, 2010). Consequently, examining how temporal variability manifests across different interval ranges provides a valuable framework for identifying subtle cognitive and perceptual alterations associated with psychopathological symptoms.

2.5. Time perception in anxiety

Anxiety can be viewed on a spectrum that includes diagnosed disorders, stable individual differences in trait anxiety, and subclinical symptoms in the general population (American Psychiatric Association, 2013; Mioni et al., 2016). At the clinical level, anxiety disorders involve intense and ongoing fear or worry that disrupts daily life (American Psychiatric Association, 2013). These disorders often relate to distortions in how time is perceived, especially in terms of overestimating how long things last and experiencing increased variability in our sense of time (American Psychiatric Association, 2013; Mioni et al., 2016). Trait anxiety refers to a more stable tendency to see situations as threatening and respond with increased anxiety, even when there is no real danger (Bar-Haim et al., 2010; Tipples, 2011). Studies show that people with higher trait anxiety have similar, though less intense, biases in their perception of time, particularly in emotionally charged or uncertain situations (Bar-Haim et al., 2010; Tipples, 2011). Subclinical anxiety symptoms are often found in non-clinical populations. These symptoms show levels of emotional distress that don’t meet the criteria for a diagnosis, but can still affect the perception and thought process. Evidence indicates that even slight increases in anxiety can result in minor changes in how we perceive time, suggesting that these time distortions exist on a broader spectrum, not just in clinical groups (Vignaud et al., 2025; Visalli et al., 2023).

Psychological time reflects both cognitive functioning and a person´s emotional state and psychological traits. Consequently, examining how individuals perceive and experience time provides a useful entry point for understanding time perception within psychopathological contexts, including the emergence and development of anxiety related process even among individuals without a formal diagnosis (Terranova et al., 2025; Vignaud et al., 2025; Visalli et al., 2023).

Research on temporal perception has consistently shown that affective disorders are linked to consistent distortions in how people experience time (Mioni et al., 2016; Vignaud et al., 2025). Anxiety is known to influence temporal judgments through alterations in emotional arousal, attentional allocation, and cognitive control processes (Mioni et al., 2016; Vignaud et al., 2025). This relationship is consistent with cognitive models of time perception, which propose that emotional arousal and attentional resources jointly influence temporal estimation through their effects on working memory and internal timing mechanisms (Brown, 2016).

Mioni et al. (2016) studied the connection between time perception and symptoms of anxiety and depression. People with higher levels of anxiety often overestimated time intervals, especially in situations that required more cognitive effort. This behavior was seen as a change in how attention and internal timing work, which are key parts of how time is perceived. In contrast, symptoms of depression showed a different pattern in how people performed with time perception. This suggests that anxiety and depression might influence the perception of in different ways. These findings support the idea that anxiety-related changes in time perception could be partly due to shifts in attention and cognitive processing.

Increased arousal associated with anxiety is thought to accelerate internal timing mechanisms, leading to a greater accumulation of temporal units and a tendency to overestimate durations. At the same time, anxiety-related attentional biases may either increase focus on temporal information or divert attention toward threat-related stimuli, depending on task demands, thereby producing variability in temporal judgments. Additionally, impairments in cognitive control and working memory may further disrupt the encoding and comparison of temporal intervals, particularly for longer durations (Bar-

Haim et al., 2007; Gable et al., 2022; Mioni et al., 2016). These findings highlight the need to study temporal perception using tasks that vary in their demands on attention, memory, and decision-making processes (Mioni et al., 2016).

Recent theoretical and empirical work has highlighted how uncertainty and unpredictability influence both anxiety and our sense of time (Grupe & Nitschke, 2013; Lake & LaBar, 2011). Anxiety is often seen as a prolonged state of heightened alertness triggered by unclear or unpredictable threats (Grupe & Nitschke, 2013). These situations have been shown to consistently distort the experience of time. Specifically, situations with unpredictable timing (i.e., not knowing when something will happen) and uncertain outcomes (i.e., not knowing if something will happen) seem to increase anxiety and are linked to greater distortions in time perception, usually resulting in time overestimations (Lake & LaBar, 2011). These findings indicate that changes in the perception of time may reflect not only emotional intensity but also uncertainty is processed. This underscores the need to consider the context and expectations when examining time perception in anxiety-related situations.

This highlights the importance of studying time perception in people with high psychological symptoms who may not qualify for a clinical diagnosis. Subtle differences in cognition and attention may already affect their sense of time before a clinical disorder appears. One example is the central-tendency bias, which is when duration estimates lean toward the average of the given intervals (Jazayeri & Shadlen, 2010; Shi et al., 2013). Participants, including individuals from non-clinical samples with varying levels of psychological traits, often display a strong central-tendency bias, with their duration estimates leaning toward the average of the tested interval. Short intervals are judged as longer while long intervals are seen as shorter, moving toward a central representation (Jazayeri & Shadlen, 2010; Shi et al., 2013). This bias is crucial in clinical studies, as individuals with anxiety might depend more on heuristics or internal assumptions when their attention is low or when uncertainty is high. Central tendency can amplify or obscure group differences in temporal judgments, underscoring the importance of careful experimental control and of interpreting bisection-point shifts in clinical samples (Treisman, 1963).

Changes in timing precision and variability can occur even when overall cognitive functioning seems intact. This sensitivity makes the bisection paradigm especially useful for studying subtle variations in psychological functioning, such as those related to depression and anxiety symptoms in non-clinical groups (Caselli et al., 2009).

Recent theoretical and experimental studies provide more evidence on how the mechanisms of attention and arousal interact in anxious individuals to affect their perception of time (Gable et al., 2022; Harana-Lahera, 2022; Sarigiannidis et al., 2020).

Mioni et al. (2016) point out that high levels of anxiety can speed up internal timing processes due to increased arousal, while also hindering attentional control. This combination can change time judgments, especially when there is a need to estimate future events. Short time intervals, which are more influenced by arousal, may be particularly vulnerable to anxiety-related distortions. Thus, anxiety is expected to affect our perception of time differently based on the length of the interval. This creates a strong reason to look at anxiety symptoms in relation to how people perform on tasks that measure short periods of time.

Anxiety is commonly associated with the feeling that time is speeding up (Droit-Volet & Meck, 2007; Tipples, 2011). Research shows that anxious people often perceive intervals as shorter than they actually are. A recent study by Sarigiannidis et al. (2020) found that participants in anxious states typically underestimated time intervals, suggesting that time passed more quickly. Notably, the same finding did not occur with fear, indicating that different negative emotions affect how individuals think about time differently (Gable & Poole, 2012; Tipples, 2011). This difference highlights that anxiety, unlike fear, may disrupt the attentional processes necessary for estimating time, making anxiety particularly significant in studying mental health and time perception.

The AGT helps clarify seemingly conflicting findings about time perception in anxiety. According to Zakay and Block (1995), increased arousal speeds up the pacemaker in internal timing systems, generating more pulses. Reduced attentional control limits the number of pulses that pass through the attentional gate (Zakay & Block, 1995). This mechanism is consistent with empirical findings showing that anxiety-related increases in arousal accelerate the pacemaker rate, leading to temporal overestimation, while attentional biases toward threat further modulate the accumulation of temporal pulses (Yuan et al., 2020). When arousal is high, people tend to overestimate durations. In contrast, when attention shifts to threat-related stimuli, fewer pulses accumulate. This leads to underestimating time and more variability in time judgments. The interaction between heightened arousal and reduced attentional control may help explain the inconsistent patterns of time distortion reported in anxiety, including findings of both temporal overestimation and underestimation across different experimental contexts (Lake et al., 2016; Mioni et al., 2016; Sarigiannidis et al., 2020; Yuan et al., 2020). This includes both overestimation (when attention is on the clock) and underestimation (when external threats pull attention) effects. (Bar-Haim et al., 2010; Lake et al., 2016; Mioni et al., 2016; Sarigiannidis et al., 2020; Tipples, 2011; Zakay & Block, 1995).

Bar-Haim et al. (2010) found that anxious individuals often show reduced attentional control, which leads to increased stimulus-driven processing when directing attention. This imbalance adds to the heightened physiological arousal typically noticed in anxiety and the well-documented tendency to focus on threatening information.

Threatening stimuli increase arousal levels and likely cause people to overestimate time because of a quicker pacemaker (Droit-Volet & Meck, 2007; Lake et al., 2016). However, if attention is too focused on the threat, fewer resources are available for timing, leading to an underestimation of time (Block & Gruber, 2014; Zakay & Block, 1995). These dual processes illustrate how anxiety can create conflicting effects on how time perception. The trends seen in anxious individuals support the idea that attention plays a significant role in anxiety-related distortions of time (Bar-Haim et al., 2010).

When making temporal judgments that require constant monitoring and the recreation of durations, anxious individuals seem less capable of dedicating stable attentional resources to timing, resulting in greater variability and lower accuracy (Bar-Haim et al., 2007; Lake et al., 2016; Mioni et al., 2016). Empirical evidence from Bar-Haim and colleagues (2010) showed that with brief exposure times (around two seconds), anxious participants perceived threatening faces as lasting longer than neutral ones. This effect aligns with heightened arousal during initial threat assessment. When the exposure extended beyond a few seconds, this difference faded, indicating either habituation or effective emotional regulation. This trend aligns with broader findings that attentional biases in anxiety are typically strongest during brief exposures (less than 1 second) and diminish as stimulus duration increases (Bar-Haim et al., 2010). Overall, these results emphasize that the feeling of time slowing down or speeding up in anxiety depends on the ongoing balance between arousal, attentional control, and exposure time.

Research by Liu and Li (2019) offered further insight into how both state and trait anxiety influence time perception. They found that individuals with high trait anxiety tended to underestimate a two-second interval when experiencing an anxious state, whereas those with low trait anxiety tended to overestimate it under the same conditions. Importantly, state anxiety itself was associated with systematic distortions in temporal judgments, with higher levels of state anxiety leading to greater timing errors and, in some cases, to the overestimation of durations, particularly for emotionally salient stimuli. These findings suggest that while trait anxiety modulates the direction of temporal bias, state anxiety amplifies distortions in time perception through mechanisms related to attentional bias and emotional arousal (Liu & Li, 2019; Liu et al., 2019). However, not all studies report consistent effects, as some findings suggest that increased state anxiety may also be associated with slight underestimations of time, highlighting the variability of temporal distortions depending on task demands and experimental context (Lueck, 2007).

The results also highlighted different underlying mechanisms: attentional processes appeared to play a central role in individuals with high trait anxiety, contributing to the underestimation of time, whereas physiological arousal seemed to be more relevant in individuals with low trait anxiety, leading to overestimation. These findings suggest that trait and state anxiety interact to influence temporal judgments through distinct cognitive and physiological pathways, resulting in increased variability and reduced accuracy in time perception (Liu & Li, 2019).

The AGM also helps explain why anxiety can have opposing effects on time perception. When anxiety diverts attention away from temporal processing toward threat-related stimuli, intervals tend to be underestimated. In contrast, when individuals allocate more attention to time while experiencing heightened arousal, temporal units accumulate more rapidly, leading to the overestimation of durations. Empirical findings support both patterns, showing that anxiety can lead to either underestimation or overestimation depending on the interaction between attentional allocation and arousal levels (Lake et al., 2016; Liu & Li, 2019).

Research on social anxiety has also shown that people with high social anxiety often overestimate how long they are exposed to socially threatening stimuli, especially when they see faces with negative expressions and direct gazes (Ishikawa & Okubo, 2016). This overestimation was strongest during short exposure. It decreased with longer displays, suggesting that initial hyperarousal and attentional capture by threats lead to early distortions in time perception, which fade as individuals adapt or regulate their emotions (Ishikawa & Okubo, 2016).

This pattern has also been demonstrated in clinical samples, where individuals with social anxiety disorder show increased temporal overestimation of threatening stimuli, particularly following experimentally induced state anxiety, highlighting the interaction between trait vulnerability and situational factors (Jusyte et al., 2015).

For socially anxious individuals, the combination of heightened arousal and focused attention on threats likely increases the number of timing pulses, leading to the feeling that time "drags" in threatening social situations (Ishikawa & Okubo, 2016). Additionally, these results align with other studies indicating that the nature and extent of time distortions in anxiety depend on how attention, emotional arousal, and context interact (Gable et al., 2022; Droit-Volet & Meck, 2007; Lake et al., 2016).

Although anxiety has often been linked to changes in time perception, the results about the direction of these changes are unclear. Some studies show that people tend to overestimate time, especially when strong physical arousal affects how they process time (Mioni et al., 2016; Yoo & Lee, 2015). Other research indicates that anxiety can lead to underestimating time, particularly when it shifts attention towards threatening information and away from tracking time (Sarigiannidis et al., 2020; Liu & Li, 2019). Rather than showing conflicting results, these findings suggest that anxiety's impact on time perception relies on how arousal, attention, and task requirements interact (Bar-Haim et al., 2010; Lake et al., 2016). Therefore, anxiety can cause people to either overestimate or underestimate duration based on the cognitive and emotional context during their time judgments.

A helpful way to understand the mixed results in the research is to look at the timing tasks used. Evidence shows that anxiety can affect how time perception, depending on how long the stimulus lasts, the demands of the task, and how much our judgments rely on arousal or attention.

Studies using short exposures to emotional or threatening stimuli often report that people feel time stretches. For instance, Bar-Haim et al. (2010) found that anxious people thought threatening facial expressions lasted longer than neutral faces during brief exposures. Similarly, Ishikawa and Okubo (2016) noted that those with high social anxiety tended to overestimate how long socially threatening stimuli lasted, especially when exposure times were short. In line with this, Jusyte et al. (2015) found greater overestimation of threatening stimuli among individuals with social anxiety disorder.

Together, these studies suggest that when it comes to short intervals and emotional stimuli, heightened arousal may make time seem to pass more slowly.

On the other hand, studies that use longer intervals or tasks that require more attention have reported more mixed results. Mioni et al. (2016) found that symptoms of anxiety were linked to distortions in temporal judgment, particularly in situations that needed more cognitive effort. Sarigiannidis et al. (2020) reported that anxious states were connected to underestimating time, implying that attention may shift away from tracking time. Likewise, Liu and Li (2019) found that the pattern of temporal distortions changed based on the interplay between state and trait anxiety, with attention playing a key role in timing tasks. These findings suggest that when timing judgments depend more on sustained attention, working memory, and executive control, anxiety may add variability and decrease accuracy instead of creating a consistent overestimation effect.

The differences in the literature may not show contradictory effects of anxiety on time perception. Instead, they likely come from variations in the cognitive demands of the tasks used, the length of the intervals judged, and the nature of the stimuli involved Lake et al., 2016; Mioni et al., 2016). Some experimental setups mainly focus on physiological arousal, while others require more attention, working memory, and executive control (Block & Gruber, 2014; Matthews & Meck, 2014). Since anxiety affects each of these processes in different ways, its impact on time judgments can change depending on the context. This can lead to findings of both overestimating and underestimating time (Lake et al., 2016; Mioni et al., 2016; Sarigiannidis et al., 2020).

The literature suggests that anxiety affects time perception, and this impact varies based on the length of the time intervals considered. In tasks that deal with shorter intervals (sub-second intervals, typically defined as lasting less than one second), increased physiological arousal is likely to speed up the internal clock. This quickening leads to more temporal pulses being counted and causes a tendency to overestimate duration (Bar-Haim et al., 2010; Droit-Volet & Gil, 2009; Yoo & Lee, 2015). As a result, individuals with higher anxiety levels probably show leftward shifts in the bisection point or give more “long” responses for short durations (Bar-Haim et al., 2010; Yoo & Lee, 2015). On the other hand, tasks involving longer intervals (supra-second intervals, typically defined as lasting more than one second) rely more on sustained attention, working memory, and executive control (Block & Gruber, 2014; Zakay & Block, 1995). Since anxiety can cause attentional instability and cognitive interference, people may devote fewer resources to timing processes. This situation can result in underestimating duration or increased variability in their responses (Block & Gruber, 2014; Sarigiannidis et al., 2020; Zakay & Block, 1995). Therefore, while anxiety can make time seem longer in short-interval tasks, it may lead to shorter or less accurate time judgments when dealing with longer durations.

2.6. Research questions and hypotheses

Previous research has consistently shown that our perception of time is affected by changes in psychological states (Droit-Volet & Meck, 2007; Grondin, 2010; Lake et al., 2016; Mioni et al., 2016). Studies indicate that emotional arousal and focus can influence internal clock mechanisms (Droit-Volet & Gil, 2009; Droit-Volet & Meck, 2007; Lake et al., 2016; Tipples, 2011), leading to the expectation that individuals with higher levels of psychological symptoms, particularly anxiety, will show consistent biases in estimating time. These biases are particularly evident in studies using the temporal bisection task, where they are reflected in shifts in the bisection point and reduced discrimination sensitivity (e.g., Caselli et al., 2009; Sarigiannidis et al., 2020). Eagleman (2008) suggested that anxiety tends to speed up the feeling of time passing.

Importantly, both recent theories and studies suggest that our perception of time varies across different time scales. Short- and long-term intervals require different levels of attention and control. These needs can be affected differently by psychological symptoms (Block & Gruber, 2014; Matthews & Meck, 2014). This distinction is especially important for temporal bisection tasks, where performance relies on the length of the intervals. However, a lot of existing research on anxiety and time perception has focused on tasks like time estimation, production, or reproduction. These tasks require more attention, memory, and motor skills. This difference in methods could lead to mixed results across studies. In this context, the temporal bisection task provides a more controlled way to examine perceptual timing processes. It emphasizes the value and potential impact of this study.

Building on this evidence, the present study aims to explore how symptoms of mental health issues, specifically anxiety, relate with time perception among university students. This population is particularly relevant, as recent research consistently reports elevated levels of anxiety in university settings, with prevalence estimates frequently exceeding 30% and reaching substantially higher levels in some samples (Malebari et al., 2024; Paiva et al., 2025; Tan et al., 2023). Moreover, large-scale surveys indicate that a significant proportion of students experience moderate to severe anxiety symptoms, highlighting this group as especially vulnerable to psychological distress and its cognitive consequences (Tan et al., 2023).

University students represent a developmental stage marked by rising demands on executive functioning, attentional control, and self-regulation. These cognitive processes are closely linked to time perception (Block & Gruber, 2014; Folker et al., 2025; Matthews & Meck, 2014; Valenzuela et al., 2020). The mix of increased psychological vulnerability and the key role of these cognitive functions makes this group especially important for studying the connection between anxiety and time perception (Tan et al., 2023; Wood et al., 2018)

The main research question for this study is: How is anxiety associated with temporal perception in university students, and does this relationship differ between sub-second and supra-second temporal bisection tasks?

It is important to preface that in the temporal bisection task, lower bisection point (BP) values show a tendency to overestimate duration. Higher BP values show a tendency to underestimate duration (Kopec & Brody, 2010; Matthews & Meck, 2014). Weber Ratio (WR) values reflect how sensitive someone is to time. Higher values mean more variability and less precision in duration judgments (Allman et al., 2014; Matthews & Meck, 2014).

Given the inconsistent findings reported in previous research, the present study adopts non-directional hypotheses regarding the relationship between anxiety symptoms and temporal performance. Nevertheless, theoretical models of time perception and empirical evidence suggest that anxiety may influence temporal judgments through alterations in physiological arousal, attentional allocation, and cognitive control processes. Because sub-second and supra-second timing rely on partially distinct cognitive mechanisms, it is also expected that the relationship between anxiety and temporal perception may differ across these two temporal ranges.

Based on the research question and literature review, the following hypotheses are proposed:

H1a. Anxiety symptoms will be associated with bisection point (BP) values in the short-interval temporal bisection task.

H1b. Anxiety symptoms will be associated with bisection point (BP) values in the long-interval temporal bisection task.

H2a. Anxiety symptoms will be associated with Weber Ratio (WR) values in the short-interval temporal bisection task.

H2b. Anxiety symptoms will be associated with Weber Ratio (WR) values in the long-interval temporal bisection task.

H3a. The association between anxiety symptoms and temporal perception, as measured by bisection point (BP), will differ between the short-interval and long-interval temporal bisection tasks.

H3b. The association between anxiety symptoms and temporal perception, as measured by Weber Ratio (WR), will differ between the short-interval and long-interval temporal bisection tasks.

This pattern is interpreted as resulting from the greater involvement of attentional and working-memory processes in longer intervals, which are known to be disrupted in anxious states (Bar-Haim et al., 2007; Block & Gruber, 2014; Grupe & Nitschke, 2013; Matthews & Meck, 2014). These hypotheses are based on models stressing the different roles of arousal and attention across various time scales and studies showing that shorter intervals are more affected by arousal, while longer intervals depend more on sustained attention and memory (Block & Gruber, 2014; Caselli et al., 2009; Eagleman, 2008; Matthews & Meck, 2016; Zakay & Block, 1995).

Therefore, this study adopts a temporal bisection approach with both short and long intervals to examine how anxiety differently affects our experience of time. By combining measurements of the bisection point and temporal sensitivity, this research may provide a clearer picture of shifts in bisection point and reduced temporal sensitivity associated with anxiety symptoms in a non-clinical setting.

3. Methods

3.1. Study design

The present study uses a quantitative, experimental, and correlational design and is part of the TEMPUS Project- *Experimental and quasi-experimental studies on subjective time perception (Temporal Cognition),* which focuses on experimental and quasi-experimental studies of subjective time perception (Gomes et al., 2025). Anxiety symptoms were measured with the Generalized Anxiety Disorder-7 (GAD-7) (Spitzer et al., 2006), and temporal perception was tested through two temporal bisection tasks based primarily on the paradigm proposed by Caselli et al. (2009), while also taking into account methodological procedures commonly adopted in previous temporal bisection studies (Aktaş & Gökçay, 2019; Gable & Poole, 2012; Liu et al., 2015). The design includes a within-subject manipulation of temporal scale. Each participant completed both a short-duration and a long-duration bisection task in a counterbalanced order. This allows us to see if the correlation between anxiety symptoms and temporal perception changes across different duration ranges.

3.2. Participants

The present study´s sample consists of 33 university students aged between 18 and 23 years (*M* = 19,42; *SD* = 1,35, recruited from a private university in Northern Portugal. Most of the participants were female (*n* = 26; 78,8%) and were enrolled in undergraduate programs (*n* = 31; 93,9%) or master's programs (*n* = 2; 6,1%). Regarding current occupation, the majority identified as full-time students (*n* = 30; 90.9%), while 9.1% (*n* = 3) were student-workers. Concerning vision status, 57.6% (*n* = 19) reported normal vision and 42.4% (*n* = 14) reported corrected vision. All of the participants reside in Portugal. Participation was voluntary, with inclusion criteria being university students aged eighteen or older. Exclusion criteria included having nervous system disorders that could affect cognitive performance and poor vision.

3.3. Instruments

3.3.1. Sociodemographic questionnaire

Sociodemographic data were collected through a self-report questionnaire designed to obtain information on participants' age, gender, educational level, occupational status, and vision status. These variables were collected to characterize the sample and, where appropriate, to be considered as control variables in subsequent analyses. The full questionnaire is presented in Appendix A.

3.3.2. Generalized Anxiety Disorder -7 (GAD-7)

GAD-7 is a self-report tool created by Spitzer, Kroenke, Williams, and Löwe in 2006. It evaluates the presence and severity of anxiety symptoms related to Generalized Anxiety Disorder, based on the criteria in the Diagnostic and Statistical Manual of Mental Disorders.

The questionnaire includes seven items, each linked to a key symptom of generalized anxiety. These symptoms are: feeling nervous or tense, having trouble controlling worry, excessive worry about various issues, difficulty relaxing, motor restlessness, irritability, and fear that something bad will happen. Participants indicate how often they have been bothered by each symptom over the past two weeks using a 4-point Likert-type response scale that ranges from 0 (Never) to 3 (Almost every day). The total GAD-7 score was calculated by summing the scores of all seven items. This score ranges from 0 to 21 points, with higher scores showing greater anxiety severity. The authors suggest cut-off points where scores from 0 to 4 indicate no or minimal anxiety, 5 to 9 indicate mild anxiety, 10 to 14 indicate moderate anxiety, and 15 to 21 indicate severe anxiety (Spitzer et al., 2006). Previous studies suggest that a score of 8 or higher may signal clinically significant anxiety symptoms (Sousa et al., 2015).

The GAD-7 shows strong internal consistency, with Cronbach's alpha values near or above .90 (Spitzer et al., 2006; Sousa et al., 2015). It also has good test-retest reliability (Spitzer et al., 2006). Construct validity is supported by significant correlations between GAD-7 scores and different measures of psychological functioning and quality of life, indicating that functional impairment increases as anxiety severity rises (Spitzer et al., 2006; Sousa et al., 2015). Additionally, factor analyses confirm that the instrument has a unidimensional structure, which supports the assessment of a single underlying concept (Sousa et al., 2015).

The Portuguese version of the GAD-7 was adjusted and validated by Sousa et al. (2015) for the European Portuguese population. This version kept the original structure of the tool, showed good acceptability, reduced completion time (about 2 to 3 minutes), and excellent psychometric qualities, with high internal consistency and evidence of convergent validity with other common anxiety measures. The Portuguese adaptation also showed sufficient sensitivity to tell apart different levels of anxiety severity, proving its value in both clinical and research settings. In this study, the GAD-7 was used as a continuous measure of anxiety symptoms.

3.3.3. Temporal Bisection Task

Subjective time perception was measured using a temporal bisection task. The task was programmed and administered using SuperLab 6.0 software in a controlled laboratory setting. Participants were seated comfortably approximately 50 cm from the computer screen.

Each participant took part in two conditions of the temporal bisection task that varied in the absolute duration of the time intervals. One condition involved short durations (less than one second), whereas the other involved long durations (more than one second). This setup followed standard practices in timing research (Caselli et al., 2009; Droit-Volet & Gil, 2009). Additionally, a three-minute break was provided between the two conditions to reduce cognitive fatigue and minimize potential carry-over effects.

Stimuli

The temporal stimulus consisted of a neutral red circle presented centrally on a white computer screen. The stimulus remained visible throughout the entire interval and disappeared immediately upon its termination. No auditory cues were provided to signal the onset or offset of the interval. This procedure ensured that temporal judgments relied exclusively on visual information, thereby minimizing the influence of multisensory timing cues, consistent with previous research recommendations. (Kopec & Brody, 2010).

Short-Duration Bisection Task

In the short-duration condition, the reference intervals included a short anchor duration of 100 ms and a long anchor duration of 600 ms. Participants had to distinguish between nine time intervals, which ranged from 100 ms to 600 ms. This included both reference durations and probe intervals that were evenly spaced across the duration range (stimuli durations: 100: 162; 225; 287; 350; 412; 475; 537 and 600 ms). Researchers often use this time scale to study sub-second interval timing processes (Caselli et al., 2009).

Long-Duration Bisection Task

In the long-duration condition, the reference intervals were set at 1000 ms for the short anchor and 3000 ms for the long anchor. Like in the short-duration task, participants differentiated between nine temporal intervals covering the entire duration range, which included reference and intermediate probe durations (stimuli durations: 1000; 1250; 1500; 1750; 2000; 2250; 2500; 2750 and 3000 ms). This supra-second temporal scale depends more heavily on attention and working memory processes (Block & Gruber, 2014; Droit-Volet & Gil, 2009).

Task Structure

Each condition of the bisection task had three steps: pre-training, training, and experimental testing, following standard temporal bisection procedures (Allan & Gibbon, 1991; Caselli et al., 2009).

In the pre-training phase, participants were exposed to the short and long reference durations two times to build stable temporal representations, without needing to respond. During the training phase, participants were exposed to five presentations of both the reference short and long stimuli and practiced classifying the reference intervals as “short” or “long” using specific response keys. To proceed to the experimental phase, participants had to meet an accuracy criterion of 90% correct responses, thereby reducing random responses and learning effects during testing.

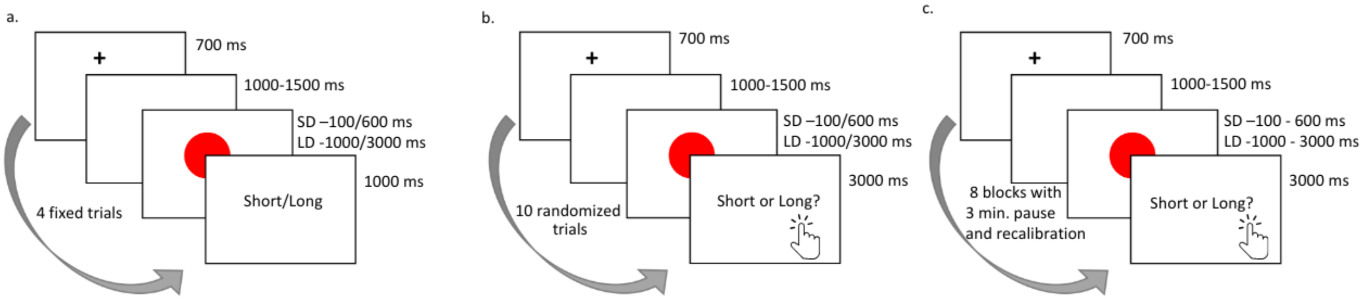
In the experimental phase, all reference (*n* = 2) and probe (*n* = 7) durations were shown in a random order across eight blocks. Thus, both the short and the long time bisection tasks consisted of 64 discrimination trials. Participants judged whether each duration was closer to the short or long reference interval. No feedback was given during this phase, except for occasional re-presentation of the reference durations at the start of the 5.º block to recalibrate temporal judgments. This method was shown to improve response stability (Caselli et al., 2009).

For the training and experimental phases, responses were made using two colored response keys on the keyboard, one blue and one yellow, corresponding to the “short” and “long” duration judgments. An overview of the temporal bisection task procedure, including the pre-training, training, and experimental phases, is presented in Figure 1.

To control for potential response biases related to motor preferences or key location, the mapping between response keys and duration categories was counterbalanced across participants. For approximately half of the participants, the blue key corresponded to the “short” response and the yellow key to the “long” response, whereas for the remaining participants this mapping was reversed.

Figure 1

Temporal Bisection Task



Note. a. Pre-training phase, b. Training phase and c. Experimental phase. Short-Duration (SD); Long-Duration (LD)

Outcome measures

For each participant and time condition, the proportion of “long” responses was plotted against stimulus duration and fitted a psychometric function (Kopec & Brody, 2010). From these functions, two main measures of time perception were extracted: the bisection point (BP), which is the duration linked to a 50% chance of a “long” response, the Difference limen (DL), that is half the difference between the intervals classified as “long” on 75% and on 25% of trials, respectively and this measures the subjective ability to discriminate between different time durations, and the Weber Ratio (WR), obtained by dividing DL by the BP, reflects time sensitivity adjusted for the estimated duration. These measures give useful information about personal time bias and the precision of discrimination. They were used as the main outcome variables in later analyses (Kopec & Brody, 2010; Caselli et al., 2009).

3.5. Procedure

The current study is part of a larger research project called TEMPUS, which focuses on experimental and quasi-experimental studies on subjective time perception. This project has received prior approval from the Ethics Committee of the Universidade Fernando Pessoa (FCHS/PI-707/27-2). All procedures followed ethical standards for research with human participants. Participants came from a non-clinical group of university students. Participants were recruited through direct in-class announcements.

University professors were first contacted, informed about the study, and granted permission for the researcher to address students during scheduled classes. Students received a brief explanation of the study's aims and procedures, and those interested volunteered their contact information to schedule participation sessions. All volunteers provided written informed consent prior to participation having declared full comprehension of the objectives of the study. Those interested in participating were contacted and scheduled for an individual session at the Cognitive Psychology Laboratory.

Participation was voluntary, and no financial compensation was given. When participants arrived at the laboratory, they were welcomed and informed about the study's general purpose. Before data collection began, all participants read and signed an informed consent form. This form outlined the study's objectives, procedures, expected duration, the voluntary nature of participation, and assurances of anonymity and confidentiality. Participants were told they could withdraw from the study at any time without penalty (OPP, 2024).

This study was conducted in accordance with ethical principles, ensuring the protection of the rights, dignity, and well-being of participants. The study is part of the TEMPUS Project that was submitted in advance to the ethics committee of Fernando Pessoa University, which evaluated and approved the research protocol before data collection began.

The confidentiality and anonymity of the data collected are also ensured. All data are encrypted and stored on secure platforms, accessible only to researchers. The information will be used exclusively for the purposes described in the protocol and destroyed after the study (OPP, 2024).

Additionally, this research adheres to the principles of beneficence and non-maleficence, ensuring that the impact of the study is minimized and that the results generated contribute to a better scientific understanding of the topic. Participants will have access to a summary of the study's main results, if they so desire, thereby reinforcing the commitment to transparency (OPP, 2024).

After giving consent, participants filled out a brief sociodemographic questionnaire and the GAD-7 questionnaire to assess anxiety symptoms. These questionnaires were completed before the experimental tasks to minimize any potential impact on self-reported anxiety levels. Next, participants took part in two conditions of the temporal bisection task using SuperLab software. Each participant completed both conditions: one with short-duration intervals and one with long-duration intervals. The order of the two tasks was counterbalanced across participants in order to control for potential order effects, such as learning, fatigue, or adaptation to the task.

At the start of each task, participants received standardized on-screen instructions detailing the task requirements and response keys. Each task contained a pre-training phase, a training phase to ensure understanding of the short and long reference durations, and an experimental phase where participants classified probe durations as being closer to either the short or the long reference interval. No feedback was given during the experimental phase. The entire experimental session lasted about 30 to 40 minutes. At the end of the session, participants were debriefed and given a chance to ask questions about the study.

3.6. Statistical Analyses

Statistical analyses were conducted using IBM SPSS Statistics (Version 31). First, descriptive statistics were computed to describe the sample and summarize the main study variables. For continuous variables, means, standard deviations, minimum values, and maximum values were calculated. Frequencies and percentages were calculated for categorical variables.

Before running inferential analyses, the distribution of the study variables was examined using the Shapiro-Wilk test. Depending on whether the assumptions of normality were met, either parametric or non-parametric statistical procedures were employed. Correlational analyses were conducted using Pearson's correlation coefficient when the assumptions for parametric testing were satisfied and Spearman's rank-order correlation coefficient when these assumptions were violated. The statistical significance was set at $\alpha = .05$ for all analyses.

To test the main hypotheses, associations between anxiety symptom severity, measured by the Generalized Anxiety Disorder 7-item scale (GAD-7), and temporal perception indices obtained from the temporal bisection tasks were examined separately for the short-duration and long-duration conditions. The analyses focused on two temporal perception measures: the Bisection Point (BP) and the Weber Ratio (WR).

It was also conducted Wilcoxon signed-rank tests for both BP and WR measures to compare temporal perception performance across the short and long-duration conditions. Furthermore, exploratory analyses were performed to see if anxiety symptom severity was linked to differences between temporal conditions. Difference scores were calculated by subtracting short-condition values from long-condition values for BP and WR measures. Then, Spearman correlations were computed between these difference scores and GAD-7 total scores.

Lastly, to investigate whether the association between anxiety symptoms and temporal perception differed across temporal conditions, linear regression models BP and WR as dependent variables. Each model included anxiety symptom severity (GAD-7 total score), temporal condition, and an interaction term between anxiety symptom severity and temporal condition (Anxiety × Condition). The interaction term was used to assess whether temporal condition moderated the relationship between anxiety symptoms and temporal perception.

4. Results

4.1. Descriptive statistics

Anxiety symptoms (GAD-7)

Descriptive statistics for GAD-7 total scores showed that participants mostly reported mild levels of anxiety symptoms. The average GAD-7 score was 7.97 (*SD* = 3.88), with a median of 7.00 and a mode of 5.00. Scores varied from 1 to 17. The descriptive statistics for GAD-7 total scores are present in Table 1. The breakdown of anxiety severity categories revealed that most participants fell into the mild anxiety range, while only a small number reported severe anxiety symptoms. Overall, these findings indicate that the sample mainly experienced mild to moderate levels of anxiety.

Table 1.

Distribution of Participants Across GAD-7 Anxiety Severity Levels

Anxiety Level	n	%
Minimal (0-4)	6	18.2%
Mild (5-9)	16	48.5%
Moderate (10-14)	10	30.3%
Severe (15-21)	1	3%

Temporal perception measures

Descriptive statistics for temporal perception measures are presented in Table 2. Overall, participants showed clear differences between the short- and long-duration temporal bisection tasks. As expected, BP and DL values were substantially higher in the long-duration condition, reflecting the longer temporal intervals used in that task. In contrast, WR values were slightly higher in the short-duration condition, suggesting greater temporal variability when participants judged shorter durations.

Table 2.

Descriptive Statistics for Temporal Perception Measures

Measure	Short Condition M (SD)	Long Condition M (SD)
BP	329.88 (75.44)	1957.45 (234.51)
WR	.23 (.11)	.16 (.07)
DL	76.76 (39.20)	315.30 (141.74)

Note. Bisection Point (BP); Weber Ratio (WR); Difference Limen (DL).

Figures 2 and 3 show the average percentage of “Long” responses for different probe durations in the short- and long-duration temporal bisection tasks. In both cases, the percentage of “Long” responses grew steadily as stimulus duration increased. For the shortest probe durations, participants rarely identified stimuli as “Long.” In contrast, the longest durations were nearly always perceived as “Long.”

Figure 2.

Proportion of Long Responses Across Probe Durations in the Short-Duration Condition

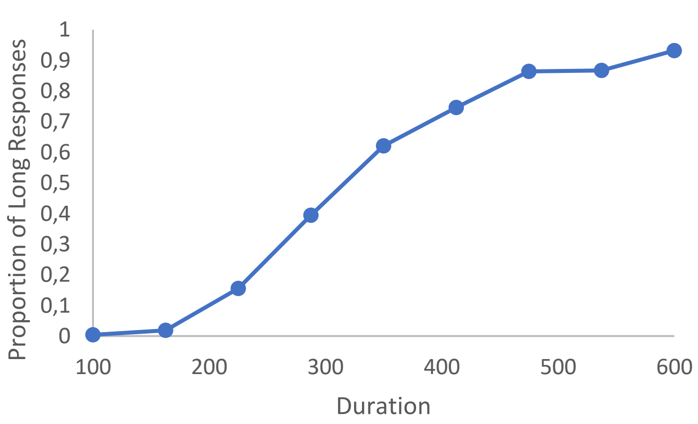
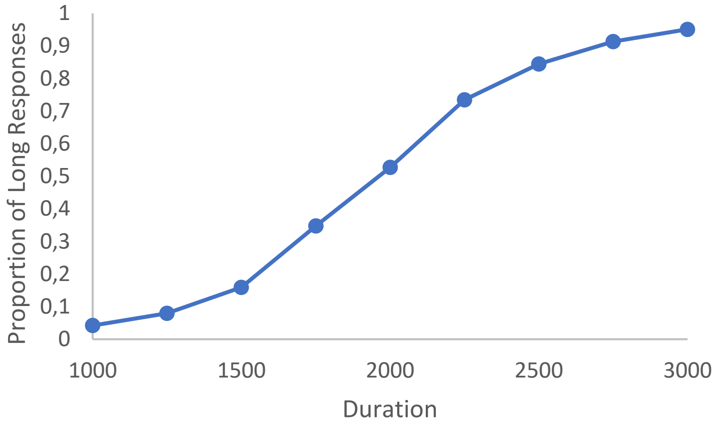


Figure 3.

Proportion of Long Responses Across Probe Durations in the Long-Duration Condition



4.2.
Associations between anxiety and temporal perception

Preliminary analysis

Shapiro–Wilk tests were conducted to assess the normality of the study variables. Results indicated significant deviations from normality for BP in both the short-duration condition, and the long-duration condition, as well as for WR in the long-duration condition (cf. Table 3). Given these violations of the normality assumption and the relatively small sample size, non-parametric analyses were used throughout the study. Specifically, Spearman's rank-order correlations were employed to examine associations between anxiety symptoms and temporal perception.

Table 3.

Shapiro–Wilk Tests of Normality for Anxiety and Temporal Perception Measures

Variable	*W*	*p*
GAD-7	.95	.19
BP-SC	.92	.03
BP-LC	.93	.04
WR-SC	.96	.25
WR-LC	.93	.03

Note. Generalized Anxiety Disorder 7-item scale total score (GAD-7_Total); Weber Ratio (WR); Short-Duration Condition (SC); Long-Duration Condition (LC).

Association between anxiety and temporal bias (BP)

To test H1, which predicted an association between anxiety symptoms and bisection point (BP) values, Spearman's rank-order correlation coefficients were calculated between GAD-7 total scores and BP measures from both short- and long-duration conditions.

The results indicated no meaningful connection between anxiety symptoms and bisection point values in the short-duration condition, *rs*(33) = .003, *p* = .987 (cf. Table 4). Likewise, no significant relationship was detected between anxiety symptoms and bisection point valuesin the long-duration condition, *rs*(33) = .240, *p* = .178. Therefore, the hypothesis (H1a and H1b) concerning the association between anxiety symptoms and BP values was not supported.

Table 4.

Spearman Correlations Between Anxiety Symptomatology and Bisection Point Measures

	GAD-7_Total	BP_SC	BP_LC
GAD-7_Total	___		
BP_SC	.003	___	
BP_LC	.240	-.119	___

Note. Generalized Anxiety Disorder 7-item scale total score (GAD-7_Total); Bisection Point (BP); Short-Duration Condition (SC); Long-Duration Condition (LC).

Association between anxiety and temporal sensitivity (WR)

To test H2, which predicted an association betweenanxiety symptoms and Weber Ratio (WR) values, Spearman's rank-order correlation were calculated between GAD-7 total scores and WR measures from both short- and long-duration conditions.

The results showed no significant correlation between anxiety symptoms and WR in the short-duration condition, r_s = .029, *p* = .875 (cf. Table 5). Similarly, there was no significant correlation between anxiety symptoms and WR in the long-duration condition, r_s = .272, *p* = .131. These findings do not support H2a or H2b, as anxiety symptoms were not significantly associated with WR values in either temporal condition.

Table 5.

Spearman Correlations Between Anxiety Symptomatology and Weber Ratio Measures

	GAD-7_Total	WR_SC	WR_LC
GAD-7_Total	___		
WR_SC	.029	___	
WR_LC	.272	-.059	___

Note. Generalized Anxiety Disorder 7-item scale total score (GAD-7_Total); Weber Ratio (WR); Short-Duration Condition (SC); Long-Duration Condition (LC).

4.3. Differences between short and long-duration conditions

To examine whether temporal perception performance differed between the short- and long-duration conditions, Wilcoxon signed-rank tests were conducted for both BP and WR measures.

Results revealed a significant difference in bisection point (BP) values between conditions, $Z = -5.01$, $p < .001$. BP values were consistently higher in the long-duration condition than in the short-duration condition (cf. Table 6).

A significant difference was also observed for Weber Ratio (WR) values, $Z = -3.09$, $p = .002$. Participants showed higher WR values in the short-duration condition compared with the long-duration condition, indicating greater temporal variability when judging shorter intervals.

Table 6.

Comparisons Between Short- and Long-Duration Conditions

Measure	Short Condition M (SD)	Long Condition M (SD)	Z	*p*
BP	329.88 (75.44)	1957.45 (234.51)	-5.01	<.001
WR	.23 (.11)	.16 (.07)	-3.09	.002

Note. Bisection Point (BP); Weber Ratio (WR).

4.4. Anxiety and temporal perception across short- and long-duration conditions

To test H3, which predicted that the association between anxiety symptoms and temporal perception would differ across temporal conditions, two linear regression models were conducted with BP and WR as dependent variables. Each model included anxiety symptom severity (GAD_Total), temporal condition, and the interaction between anxiety symptom severity and temporal condition (Anxiety × Condition).

For BP, a significant main effect of temporal condition emerged, $B = 1534.88$, $p < .001$, indicating differences in BP values between the short- and long-duration conditions. However, neither anxiety symptoms, $B = 0.65$, $p = .94$, nor the Anxiety × Condition interaction, $B = 11.63$, $p = .30$, reached statistical significance.

Similarly, for WR, a significant main effect of temporal condition was observed, $B = -0.12$, $p = .032$, indicating differences in temporal sensitivity across conditions. Neither anxiety symptoms, $B = 0.002$, $p = .63$, nor the Anxiety × Condition interaction, $B = 0.005$, $p = .37$, were statistically significant.

As shown in Table 7, the interaction between anxiety symptoms and temporal condition was not statistically significant for either BP or WR. Therefore, H3 was not supported. These findings suggest that the relationship between anxiety symptoms symptoms and temporal perception did not differ between the short-duration and long-duration temporal bisection tasks.

Table 7.

Linear Regression Models Examining the Interaction Between Anxiety Symptoms and Temporal Condition

Dependent Variable	**Predictor**	**B**	**t**	**p**
BP	GAD-7_Total	0.65	0.08	.94
	Condition	1534.88	15.51	<.001
	GAD-7 x Condition	11.63	1.04	.30
WR	GAD-7_Total	0.002	.49	.63
	Condition	-0.12	-2.20	.03
	GAD-7 x Condition	0.005	.91	.37

Note. BP = Bisection Point; WR = Weber Ratio. Condition was coded as 0 = short-duration condition and 1 = long-duration condition.

5. Discussion

The current study aimed to look at the correlation between anxiety symptomatology and how university students perceive time. It used temporal bisection tasks with short and long time intervals. Specifically, the study focused on whether anxiety symptoms led to consistent errors in time judgments, measured through changes in bisection points (BP) and temporal sensitivity represented by Weber Ratios (WR). In addition, although significant differences were observed between the short- and long-duration conditions for both BP and WR measures, temporal condition did not moderate the relationship between anxiety symptoms and temporal perception.

Overall, the findings did not support the proposed hypotheses. Anxiety symptom severity was not significantly associated with BP or WR values in either temporal condition, and temporal condition did not moderate these associations. However, these findings should be interpreted in light of the characteristics of the sample, as most participants reported mild levels of anxiety symptoms. Similarly, demographic variables had limited connections with measures of time perception. Although these findings differ from some previous studies reporting anxiety-related distortions in temporal processing, they contribute to a growing body of literature suggesting that the relationship between anxiety and time perception may be influenced by methodological, contextual, and individual factors.

These findings do not completely match previous research that suggests anxiety may affect time judgments by influencing physiological arousal and attentional processes (Droit-Volet & Meck, 2007; Mioni et al., 2016; Sarigiannidis et al., 2020). However, research on anxiety and time perception has produced mixed results. Some studies found that anxious individuals tend to overestimate durations (Mioni et al., 2016; Tipples, 2011), while others noted underestimation or increased variability in time judgments (Sarigiannidis et al., 2020; Liu & Li, 2019). These differences suggest that the link between anxiety and time processing may depend on various methodological and contextual factors, such as task demands, attentional needs, emotional relevance, duration range, and the specific type of anxiety being evaluated. In this study, anxiety symptom severity was not significantly linked to bisection point performance in either temporal condition.

The lack of significant associations in this study could be partly due to the characteristics of the sample and the type of anxiety assessed. Unlike many earlier studies that looked at clinical groups or anxiety induced in a lab setting, this study focused on anxiety symptom severity in a non-clinical group of university students. Participants reported relatively mild anxiety levels on average (M = 7.97), and anxiety was measured using the GAD-7, which mainly captures recent symptoms rather than state or stable trait anxiety (Spitzer et al., 2006). Therefore, the findings should be understood in the context of self-reported anxiety symptom severity and cannot be generalized to other types of anxiety commonly studied in temporal perception, such as state or clinical anxiety (Endler & Kocovski, 2001). One possible interpretation is that there may be a threshold effect in the link between anxiety and temporal perception. The internal timing system might be fairly resilient to the everyday worries typical for university students, with noticeable distortions appearing only when anxiety reaches moderate or severe levels, as seen in clinical groups (Bar-Haim et al., 2007; Mioni et al., 2016). This interpretation aligns with findings that suggest subclinical anxiety is linked to more subtle cognitive changes that can be hard to detect using behavioral measures alone (Visalli et al., 2023; Vignaud et al., 2025).

Moreover, the temporal bisection task mainly relies on perceptual discrimination and comparative judgments while limiting explicit estimation and motor demands (Kopec & Brody, 2010). Therefore, it's possible that the task in this study lessened the impact of attentional and cognitive biases typically correlateded with anxiety symptoms. The psychometric functions from both temporal conditions showed that participants regularly increased their proportion of "Long" responses as the stimulus duration grew. This pattern is typical of successful performance in temporal bisection tasks and suggests that participants could tell the difference between shorter and longer intervals in both temporal ranges (Kopec & Brody, 2010; Allman et al., 2014). Therefore, the lack of significant links with anxiety symptoms likely does not mean participants failed to understand or complete the task. Instead, it points to no clear relationship between the severity of anxiety symptoms and temporal perception in this sample.

Matthews and Meck (2014) further suggest that temporal performance results from the interaction of several cognitive mechanisms instead of a single timing process, which might add to the variability in the findings.

These results do not completely match earlier studies that suggest anxiety might lead to less precise temporal processing. Research on temporal perception in anxious individuals often shows greater variability and lower temporal sensitivity (Bar-Haim et al., 2007; Lake et al., 2016; Mioni et al., 2016; Sarigiannidis et al., 2020). This implies that anxiety-related thought patterns can disrupt the consistency of time judgments (Mioni et al., 2016; Sarigiannidis et al., 2020). In the temporal bisection test, higher WR values generally indicate lower ability to tell time intervals apart and shallower psychometric functions, which point to increased internal variability during timing tasks (Liu et al., 2022; Sarigiannidis et al., 2020).

Nonetheless, the lack of significant results in the present study may imply that subclinical anxiety symptoms do not greatly impact the mechanisms of temporal sensitivity in non-clinical groups. As mentioned in the theoretical framework, subtle anxiety symptoms might have weaker cognitive effects than those typically seen in clinical groups or in situations that induce anxiety in a lab setting (Visalli et al., 2023; Vignaud et al., 2025).

An important consideration is the statistical power of this study. The observed associations did not reach statistical significance. However, this does not mean that it can be definitively said that no relationship exists between anxiety symptoms and how people perceive time. The small sample size and limited range of anxiety symptom severity might have reduced the study's ability to detect subtle effects.

The current findings suggest a lack of evidence for the proposed relationships, rather than proof that these relationships do not exist. Future studies with larger and more diverse samples are needed to determine if anxiety and temporal perception are truly unrelated, or if this study did not have enough sensitivity to find small effects.

Although anxiety symptoms were not significantly linked to BP or WR measures in either time condition, the correlation coefficients were consistently higher in the long-duration condition compared to the short-duration condition. Since supra-second timing demands more from attention, working memory, and executive control processes (Caselli et al., 2009; Matthews & Meck, 2014), this pattern may tentatively indicate that anxiety plays a bigger role when temporal judgments depend on higher-level cognitive resources. However, this interpretation should be taken with caution. The observed links did not reach statistical significance. The regression analyses showed no significant Anxiety × Condition interaction, and the relatively small sample size may have reduced the statistical power to identify subtle effects. Therefore, the current findings should be seen as a lack of evidence for the proposed links rather than proof that such links do not exist.

This result contrasts with theories that suggest anxiety might speed up internal timing mechanisms, especially for shorter intervals. According to the internal clock model (Gibbon et al., 1984), increased physiological arousal could boost the speed of the pacemaker, leading to a higher accumulation of temporal pulses and creating the feeling of longer durations. Similarly, Droit-Volet and Meck (2007) suggested that emotional and anxiety-driven states might change time judgments by affecting arousal and attention.

Based on these ideas, individuals with higher anxiety levels should perceive time intervals as longer than they are, which would result in lower BP values.

Previous studies have also found evidence that individuals with anxiety or high emotional arousal tend to overestimate time (Mioni et al., 2016; Tipples, 2011). These findings are often viewed through attention-driven frameworks, indicating that threatening or emotionally significant states increase focus on internal bodily sensations and external stimuli, thus changing how time is processed (Bar-Haim et al., 2007; Droit-Volet & Gil, 2009).

However, the lack of significant findings in our study suggests that short time intervals might be less affected by subclinical anxiety symptoms. Earlier research shows that shorter intervals are typically seen as more automatic and based on perception, relying less on complex cognitive processes like working memory and sustained attention (Caselli et al., 2009; Matthews & Meck, 2014). Therefore, the more automatic nature of processing short durations may have diminished the role of anxiety-related cognitive biases in the sample.

Previous studies suggest that how time is processed may vary depending on the duration being measured. Unlike shorter intervals, which mainly depend on automatic perceptual processes, longer durations seem to require more focus, working memory, and executive functioning (Caselli et al., 2009; Matthews & Meck, 2014). As a result, anxiety-related thinking may have a greater impact on judgments about longer time intervals.

Importantly, the interaction analyses provided no evidence that temporal condition moderated the relationship between anxiety symptoms and temporal perception. Although theoretical accounts distinguish between sub-second and supra-second timing mechanisms and propose that longer intervals rely more heavily on attentional and executive resources (Caselli et al., 2009; Matthews & Meck, 2014), the present findings suggest that anxiety symptom severity did not differentially influence temporal processing across these temporal ranges. Thus, H3 was not supported.

The findings provide limited support for predictions derived from the Attentional-Gate Model (Zakay & Block, 1995), as anxiety symptoms were not associated with systematic distortions in temporal judgments. This suggests that the attentional demands generated by mild anxiety symptoms may not have been sufficient to disrupt temporal processing in the present sample.

Additionally, prior research on anxiety and time perception has produced mixed results for longer durations. Some studies reported time distortions correlated to anxious states (Mioni et al., 2016; Sarigiannidis et al., 2020), while others suggested that the effects of anxiety might vary based on context and task demands rather than being consistent across all time ranges. These inconsistencies were noted in the theoretical framework and imply that time distortions may arise from complex interactions between arousal, attention, and cognitive control.

Differences between the current findings and those reported by Mioni et al. (2016) may partly come from the different methods used in their tasks. Mioni et al. (2016) employed temporal production and reproduction tasks. These require participants to actively encode, keep, and reproduce temporal information. This places heavy demands on attention, working memory, and monitoring strategies. In contrast, the temporal bisection task used in this study mainly focuses on distinguishing between different durations. This task may be more resistant to cognitive disruptions linked to mild anxiety symptoms. As a result, the effects of anxiety seen in production and reproduction tasks might not appear as clearly in temporal bisection tasks. This could help explain why there are no significant associations in the current sample.

The current findings may help us understand how students behave in academic settings. While mild anxiety symptoms did not seem to alter basic time perception, this does not mean that anxiety does not matter for academic performance. Previous studies show that anxiety can harm time management, procrastination, focus, and academic success through factors like attention control, emotional regulation, and decision-making, not through changes in timing processes (Beiter et al., 2015; Auerbach et al., 2018). Thus, the lack of effects on time perception should not be taken as proof that anxiety does not affect students' everyday functioning or academic success.

Although there was a positive relationship between anxiety symptoms and BP in the long-duration condition, this connection was not statistically significant. Therefore, these findings do not support a correlation between the severity of anxiety symptoms and temporal bias in either of the temporal conditions.

Overall, the present findings did not support the proposed hypotheses regarding the association between anxiety symptoms and how people perceive time. Anxiety symptoms were not significantly associated with either BP or WR values in the short or long duration temporal bisection tasks. Furthermore, although significant differences were observed between temporal conditions for both BP and WR measures, temporal condition did not moderate the relationship between anxiety symptoms and temporal perception. Consequently, there was no evidence that anxiety symptoms differentially influenced temporal processing across sub-second and supra-second intervals.

Although these findings do not support predictions derived from theoretical models emphasizing the role of anxiety in temporal processing, they are consistent with the view that temporal judgments emerge from the interaction of multiple cognitive and emotional systems, including arousal, attention, working memory, and executive functioning (Matthews & Meck, 2014; Zakay & Block, 1997). The absence of significant effects in the present study suggests that mild anxiety symptoms, such as those observed in this predominantly non-clinical sample, may not be sufficient to produce measurable distortions in temporal perception.

Despite the lack of significant associations, this study contributes to the literature by examining anxiety symptoms and subjective time perception in a non-clinical university sample and by directly comparing performance across sub-second and supra-second temporal ranges. Future research should employ larger and more diverse samples, include broader levels of anxiety severity, and further investigate the conditions under which anxiety may influence temporal judgments. Such efforts may help clarify whether the null findings observed in the present study reflect a genuine absence of association or the limited ability to detect small effects within this sample.

6. Conclusion

Starting with the idea that time perception is shaped by emotional, attentional, and cognitive factors, this study explored the correlation between anxiety symptoms and time perception among university students. Specifically, it looked at whether anxiety symptoms were related to errors in time judgments, as shown by changes in bisection point (BP) and temporal sensitivity measured by Weber Ratios (WR) for both short and long time periods.

The findings did not support the proposed hypotheses. Anxiety symptoms was not significantly associated with BP or WR values in either short or long conditions. Furthermore, although significant differences were observed between short- and long-duration conditions for both BP and WR measures, temporal condition did not moderate the relationship between anxiety symptoms and temporal perception. Thus, anxiety symptoms did not differentially influence temporal processing across sub-second and supra-second intervals.

In contrast, there were significant differences between the short and long duration conditions. Participants had higher BP values and lower WR values in the long-duration condition. This suggests that temporal processing varies across different time scales. These findings are consistent with theoretical accounts proposing that sub-second and supra-second timing rely on partially distinct cognitive processes and place different demands on attentional and executive resources.

Although these findings do not fully align with studies reporting anxiety-related distortions in temporal perception, they contribute to the limited literature on non-clinical populations and suggest that the relationship between anxiety and time perception may be weaker, or more context-dependent, or more sensitive to methodological factors than some theoretical models imply. As discussed in this study, time distortions tied to anxiety may depend on many factors, such as symptom severity, contextual demands, duration range, attention focus, and the nature of the tasks used.

From a practical perspective, the findings suggest that mild anxiety symptoms may not be sufficient to produce measurable distortions in basic temporal perception processes among university students. However, given the well-established impact of anxiety on attention, emotional regulation, decision-making, and academic functioning(Auerbach et al., 2018; Beiter et al., 2015), promoting student mental health remains an important priority within higher education settings.

Several limitations should be noted. First, the small sample size may have lowered statistical power and made it harder to find small or moderate links between anxiety symptoms and temporal perception. Because of this, the lack of statistically significant findings should be viewed carefully. Non-significant results do not automatically mean there is no relationship between the variables being studied. Larger samples may be needed to find out if the observed patterns represent true null effects or links that could not be detected in this study.. Additionally, the sample was mostly female and consisted solely of university students, which limits how applicable the findings are to the larger population.

Another limitation involves assessing anxiety with the GAD-7. While the tool is commonly used and shows strong measurement qualities, it mainly evaluates generalized anxiety symptoms experienced over the last two weeks. It may not effectively capture brief changes in anxiety during task performance. Temporal perception models often highlight the importance of state-dependent processes, such as physiological arousal and attention, which were not directly measured in this study. As a result, the GAD-7 might not have been sensitive enough to identify the specific aspects of anxiety that are most relevant to temporal processing. The non-clinical nature of the sample should be taken into account, as the anxiety levels may not have been high enough to affect internal timing processes.

Future research should tackle several limitations found in this study. First, we need studies with larger samples and more variety in anxiety symptom severity to see if the small associations noted in the long-duration condition become statistically reliable. Second, upcoming investigations could pair the GAD-7 with measures of state anxiety or trait anxiety (Spielberger, 1983). This would help us better differentiate between chronic anxiety symptoms and brief emotional states during tasks. Given the importance of attention and arousal in perceiving time, future studies should also include physiological indicators, such as heart rate variability or skin conductance, along with cognitive measures of sustained attention and working memory (Droit-Volet & Meck, 2007; Zakay & Block, 1995). These methods may clarify if anxiety affects time perception indirectly by using cognitive resources instead of changing our internal timing mechanisms (Caselli et al., 2009; Matthews & Meck, 2014). Finally, more research in non-clinical populations is crucial since relatively few studies have looked at the link between anxiety symptoms and time perception outside of clinical settings (Vignaud et al., 2025; Visalli et al., 2023).

In conclusion, the present study found no evidence that anxiety symptom severity was associated with temporal bias or temporal sensitivity in either sub-second or supra-second temporal bisection tasks. Although significant differences emerged between temporal conditions, anxiety did not differentially influence temporal processing across temporal scales. These findings contribute to the growing literature on temporal perception in non-clinical populations and highlight the importance of considering both individual characteristics and contextual factors when investigating the relationship between emotional functioning and subjective time perception.

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Appendixes

Appendix A – Evaluation Protocol

Perceção da passagem do tempo e ansiedade: Um estudo em estudantes universitários

O presente estudo tem como **objetivo geral** analisar a relação da ansiedade na experiência subjetiva da passagem do tempo e respetiva influência na distorção temporal, em estudantes universitários.

Assim, se tens **18 ou mais anos de idade** e se estiveres a **frequentar um curso superior**, gostaríamos de te convidar a participar na presente investigação. *A tua colaboração é muito importante!*

A participação é **voluntária** e **sem riscos**, e podes desistir em qualquer altura. Esta participação divide-se em dois momentos:

- No **primeiro momento**, é solicitado que preenchas o presente protocolo de avaliação, constituído por várias questões sobre ti e sobre o modo como sentes e pensas em relação às variáveis acima indicadas. Não há respostas certas nem erradas. Pedimos, apenas, que respondas da forma mais objetiva, rigorosa e sincera possível. O tempo médio estimado de preenchimento é de 10 a 15 minutos.

- No **segundo momento**, é solicitado que realizes uma tarefa de bissecção temporal, também no computador, que consiste em indicar se os estímulos apresentados têm uma duração de tempo curta ou longa. O tempo médio estimado para esta experiência é de 30 minutos, devendo a mesma ser realizada imediatamente a seguir ao preenchimento do presente protocolo de avaliação.

Nota que as respostas são totalmente **confidenciais** e **anónimas** e a informação recolhida destina-se exclusivamente para **fins académicos** e de **investigação**.

Este estudo está a ser realizado pela Margarida Inês de Carvalho Pinto, sob orientação da Prof. Doutora Carina Fernandes e da Prof. Doutora Inês Gomes, para conclusão do mestrado em Psicologia Clínica e da Saúde, na Universidade Fernando Pessoa. Ele insere-se no âmbito de um projeto de investigação mais amplo denominado "**Do tempo que voa ao tempo que não passa: Estudos experimentais sobre a perceção subjetiva do tempo**" (projeto **TEMPUS**).

Informações adicionais poderão ser obtidas através dos seguintes e-mails: 42422@ufp.edu.pt para informações sobre o presente estudo ou igomes@ufp.edu.pt para informações sobre o projeto de investigação TEMPUS.

Muito obrigada pela tua colaboração!

Para participar neste estudo declaro que: *

- [ ] Compreendi a explicação sobre a investigação e as condições de participação.
- [ ] Tenho 18 ou mais anos de idade.
- [ ] Consinto em participar voluntariamente no estudo, em ambos os momentos de avaliação (preenchimento do protocolo de avaliação e realização da experiência laboratorial).

Questionário Sócio-Demográfico e de Saúde

I- Dados Pessoais

I.1. Idade *

A sua resposta

I.2. Sexo *

- ○ Feminino
- ○ Masculino

I.3. Grau do ciclo de estudos que frequenta *

- ○ Curso Técnico Superior Profissional (CTeSP)
- ○ Licenciatura
- ○ Mestrado Integrado
- ○ Mestrado

◯ Doutoramento

I.6. Situação atual *

◯ Estudante

◯ Trabalhador-Estudante

I.7. Língua materna *

◯ Portuguesa

◯ Outra: ______________________

I.8. Lateralidade (mão dominante) *

◯ Dextra (Direita)

◯ Canhota (Esquerdino)

◯ Ambidextra (Mista)

◯ Não definida

Questionário Sócio-Demográfico e de Saúde

II - Saúde

II.1. Tem diagnóstico atual de doença neurológica e/ou psiquiátrica *

◯ Não

◯ Sim

II.2. Em caso afirmativo, indique qual ou quais os diagnósticos atuais

A sua resposta

II.3. Toma atualmente medicação *

- Não
- Sim

II.4. Em caso afirmativo, indique para que efeito

A sua resposta

II.5. Condição visual atual *

- Visão normal (sem necessidade de correção)
- Visão corrigida (uso de óculos, lentes de contacto)
- Défice visual sem correção

GAD-7 (Sousa et al., 2015)

Responda, por favor, a todas as afirmações que se seguem e, com base nos **últimos 15 dias**, selecione a opção que considera mais adequada.

1. Durante os últimos 15 dias, quanto foi afetado pelo seguinte problema: *
Senti-me nervoso, ansioso ou no limite.

Selecionar

2. Durante os últimos 15 dias, quanto foi afetado pelo seguinte problema: *
Fui incapaz de parar de me preocupar ou de controlar as preocupações.

Selecionar

3. Durante os últimos 15 dias, quanto foi afetado pelo seguinte problema: *
Preocupei-me demais com diferentes assuntos.

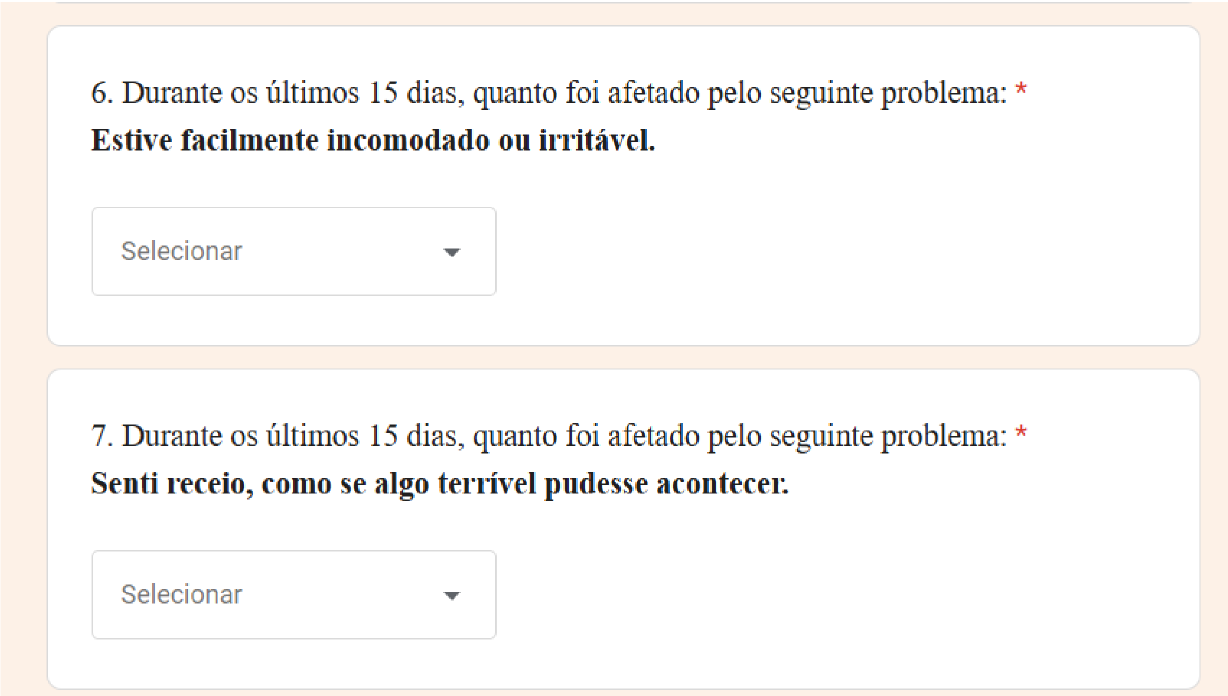
Selecionar

4. Durante os últimos 15 dias, quanto foi afetado pelo seguinte problema: *
Tive dificuldade em relaxar.

Selecionar

5. Durante os últimos 15 dias, quanto foi afetado pelo seguinte problema: *
Estive tão inquieto que era difícil ficar sossegado.

Selecionar



6. Durante os últimos 15 dias, quanto foi afetado pelo seguinte problema: *
Estive facilmente incomodado ou irritável.

Selecionar

7. Durante os últimos 15 dias, quanto foi afetado pelo seguinte problema: *
Senti receio, como se algo terrível pudesse acontecer.

Selecionar