ANDREIA FILIPA CARMO DIAS

I WAS THINKING ABOUT SOMETHING ELSE: ASSESSING MIND WANDERING IN SCHOOL-AGED CHILDREN

UNIVERSIDADE DO ALGARVE

Faculdade de Ciências Humanas e Sociais

2024

ANDREIA FILIPA CARMO DIAS

I WAS THINKING ABOUT SOMETHING ELSE: ASSESSING MIND WANDERING IN SCHOOL-AGED CHILDREN

Mestrado em Neurociências Cognitivas e Neuropsicologia

Trabalho efetuado sob a orientação:

Professora Doutora Filomena Café Inácio

Professor Doutor Luís Miguel Madeira Faísca

UNIVERSIDADE DO ALGARVE

Faculdade de Ciências Humanas e Sociais

2024

I WAS THINKING ABOUT SOMETHING ELSE: ASSESSING MIND WANDERING IN SCHOOL-AGED CHILDREN

Declaração de Autoria de Trabalho

Declaro ser a autora deste trabalho, que é original e inédito. Autores e trabalhos consultados estão devidamente citados no texto e constam da listagem de referências incluída.

Assinatura

(Andreia Dias)

Copyright © Andreia Filipa Carmo Dias

A Universidade do Algarve reserva para si o direito, em conformidade com o disposto no Código do Direito de Autor e dos Direitos Conexos, de arquivar, reproduzir e publicar a obra, independentemente do meio utilizado, bem como de a divulgar através de repositórios científicos e de admitir a sua cópia e distribuição para fins meramente educacionais ou de investigação e não comerciais, conquanto seja dado o devido crédito ao autor e editor respetivos.

Agradecimentos

À Catarina e ao Parker

À minha família

Aos meus amigos

Aos professores Filomena e Faísca

Ao Fábio e à Clarice

A todas as crianças que participaram no estudo, aos professores e funcionários do Agrupamento de escolas Dr. Jorge Augusto Correia - Tavira

Resumo

Mind wandering, ou a divagação mental, é um fenómeno humano universal descrito como uma mudança de atenção de uma tarefa em curso para pensamentos gerados internamente. Sendo assim, ocorre quando estamos a fazer uma tarefa e começamos a pensar em outra coisa. Esta experiência consume grande parte do nosso dia-a-dia. Estima-se que os adultos passam 30 a 50% do seu tempo em divagação mental, enquanto as crianças passam cerca de 20 a 33% do seu tempo a divagar.

A nível mundial, cada vez mais tem crescido o número de estudos acerca da divagação mental. Ao longo dos anos foram surgindo várias definições relativas à divagação mental, sendo a mais operacionalizada a *Task-Unrelated Thoughts*, que descreve a divagação mental como pensamentos que não estão relacionados com a tarefa. A divagação mental pode acontecer de forma intencional, quando o indivíduo escolhe deixar os seus pensamentos divagarem, ou de forma não intencional, quando é espontânea, ocorrendo mesmo quando estamos a tentar prestar bastante atenção à tarefa que estamos a fazer.

Não se sabe exatamente o porquê da nossa mente divagar, mas podemos tentar avaliar a divagação mental através de métodos subjetivos ou de métodos objetivos. Num dos métodos subjetivos, é perguntado ao participante que se encontra a realizar uma tarefa se a sua atenção num dado momento está focada na tarefa ou se estava a pensar em outra coisa (*probe-caught method*). Outro método de avaliação solicita ao participante que reporte espontaneamente quando está em divagação metal (*self-caught method*). Ambos os procedimentos envolvem a interrupção da tarefa em curso. O *retrospective method* implica recolher retrospetivamente dados sobre a frequência da divagação mental através de questionários. Existem também métodos objetivos tais como detetar a divagação mental através de indicadores somáticos ou neurofisiológicos, nomeadamente através dos movimentos oculares, dilatação da pupila, frequência cardíaca, marcadores neurais (através da eletroencefalografia) ou pela análise das expressões faciais. Nos adultos, os estudos de neuroimagem e a investigação comportamental têm confirmado a validade dos métodos subjetivos por autorrelato. Há também estudos que mostram que crianças a partir dos 8 anos são capazes de identificar quando a sua mente divaga e descrever o conteúdo do seu pensamento. Neste sentido, será importante usar mais de um método para tentar avaliar de forma precisa a frequência de divagação mental.

Vários estudos tentam explorar a relação entre a divagação mental e o desempenho cognitivo. Por um lado, temos autores que encontraram estar a divagação mental associada a processos benéficos, como o aumento da criatividade, ajuda na resolução de problemas e na planificação. Por outro lado, a divagação mental pode ter um efeito negativo em tarefas que envolvem a atenção sustentada e memória de trabalho, como, por exemplo, a leitura. A aprendizagem baseia-se na aquisição de conhecimentos e na integração desses novas nossas aprendizagens com conhecimentos prévios e a divagação mental pode interferir nesse processo. Apesar do seu evidente impacto educativo, poucos estudos investigam a divagação mental em crianças.

A grande maioria dos estudos usa os adultos como população alvo, resultando em poucos estudos a caracterizar a divagação mental nas crianças. Deste, modo, o objetivo do presente estudo é explorar a possibilidade de avaliar a divagação mental em crianças portuguesas e determinar se existe associação entre a divagação mental e o desempenho cognitivo destas crianças.

A amostra incluiu 48 crianças com idades compreendidas entre os 8 e os 11 anos. Foi feita uma atividade de treino, seguida de uma tarefa de detenção de divagação mental. Esta tarefa foi adaptada para o português e nela os participantes viam e ouviam um vídeo gravado onde se narrava uma história sobre o Egito Antigo. Durante esta narrativa foram feitas seis interrupções (*probe-thoughts*) para questionar os participantes se estavam a pensar na história narrada no momento imediatamente anterior à interrupção ou se estavam a pensar em outra coisa. Caso estivessem a pensar na história, respondiam a duas perguntas simples. Se estivessem a pensar noutra coisa, tinham de dizer aquilo em que estavam a pensar e se esse pensamento divergente ocorrera intencionalmente ou simplesmente surgira na sua cabeça. Durante este procedimento, os participantes eram filmados para registar a sua expressão facial, sendo também registada a sua frequência cardíaca com recurso a um *smartwatch.* No final da narrativa, eram feitas oralmente dez perguntas de resposta fechada acerca da história, para assegurar o grau de atenção à mesma. Finalmente, foram aplicadas, pela mesma ordem, seis provas de avaliação cognitiva (memória de dígitos, fluência verbal fonémica e semântica, trilhas, matrizes progressivas coloridas de *Raven,* teste de *Stroop* com frutas), e, por fim, o questionário de divagação mental.

Os resultados revelam que os participantes relatam estar em divagação mental em aproximadamente 16% do tempo em que estão a fazer a tarefa. Normalmente a mente

divaga de forma não intencional, ou seja, a divagação acontece mesmo quando as crianças estão a tentar prestar atenção. Foi encontrada uma correlação positiva moderada entre a medida de divagação mental durante a tarefa e a medida de divagação mental do dia-a-dia, o que sugere que as crianças que divagam menos durante uma tarefa são também aquelas que apresentam menos propensão para divagar no seu quotidiano. No entanto, não foram encontradas associações entre as duas medidas de divagação mental e as provas cognitivas, a idade, género, nem com as medidas relativas ao batimento cardíaco.

Embora os estudos sobre a divagação mental tenham aumentado na última década, continua a ser necessário desenvolver investigação para compreender melhor este fenómeno humano. Seria importante que, em estudos futuros, se elaborassem métodos que avaliassem com precisão a divagação mental e se clarificassem os fatores associados a uma maior divagação mental. Desta forma, será possível maximizar ou diminuir a divagação mental, dependendo da situação em que nos encontramos e dos nossos objetivos.

Palavras-chave: Divagação mental; Pensamentos não relacionados com a tarefa; Crianças com desenvolvimento neuro típico; Desempenho cognitivo.

Abstract

Mind Wandering (MW) is an everyday human experience, known as a shift of attention from the current task to internally generated thoughts. Research on daily-life mind wandering shows that it consumes a big part of our time. In adults and adolescents, it is associated with poorer performance in educationally significant tasks. This study aims to explore the possibility of assessing mind wandering in primary school children and to determine its association with cognitive performance. A sample of 48 Portuguese children aged 8–11 years engaged in a listening/visual activity, while the frequency of mind wandering was measured using intermittent thought probes. Participants then completed a memory retention test and other cognitive tests. Children reported being engaged to mind wandering 16% of the time. The results indicate a positive correlation between the measure of MW during an ongoing task and the retrospective measure of MW in daily life but there's no significant association between MW measures and cognitive performance, heart rate, age, or gender.

Keywords: Mind Wandering; Task unrelated thoughts; Typically developing children; Cognitive performance.

Index

Figure Index

Graph Index

Table Index

Index of Annexes

List of Abbreviations

AUs - Facial Action Units

EEG - Electroencephalogram

ERP - Event-Related Potentials

MW – Mind Wandering

MWQ - The Mind Wandering Questionnaire

SART - Sustained Attention to Response Task

SIT - Stimulus-Independent Thought

SITUT - Stimulus-Independent Task-Unrelated Thought

SPSS - Statistical Package for the Social Sciences

TUTs- Task-Unrelated Thoughts

1. Introduction

Mind Wandering (MW) is an everyday human experience (Frick et al., 2020; Wong et al., 2022), known as a shift of attention from the current task to internally generated thoughts (Smallwood & Schooler, 2006). It may happen while you're reading a book and at the end of the page, you gather that your mind has wandered to other topics.

Research on daily-life mind wandering shows that it consumes a generous amount of our time (Kane et al., 2017). It has been estimated that adults spend approximately 30-50% of their daily lives participating in MW, while a smaller percentage (20-33%) has been found in children (Cherry et al., 2022). MW can occur in two different formats, intentional and unintentional. Intentional mind wandering happens when individuals choose to let their thoughts drift away from the here and now. Unintentional MW is spontaneous and can occur even when people try their best to concentrate on the current task (Murray & Krasich, 2022).

Mind Wandering may be seen as advantageous for evolution by enabling individuals to reflect on unachieved goals, to employ creative thinking to solve problems (Simonton, 2018), and also relieving tedium (Mooneyham & Schooler, 2013). However, such gains achieved by MW appear to be offset by noticeable cognitive performance costs (Mooneyham & Schooler, 2013). Additionally, MW is negatively correlated with reading (Unsworth & McMillan, 2013), list learning (Peterson & Wissman, 2020), and impaired performance in daily life (McVay et al., 2009).

1.1 Definition of MW

Past studies display different definitions of MW. *Task-Unrelated Thoughts* (TUTs) definition described MW as thoughts that aren’t related to the current task (Smallwood & Schooler, 2006). This approach enables one to find contexts requiring people to pay attention to tasks, to see the cost of attention failures, and helps to understand the involvement of MW in daily activities (Kane et al., 2017). Nevertheless, doesn’t take into account all experiences that people identify as mind wandering.

MW can also be seen as unintentional thoughts. However, this viewpoint has been criticized because it overlooks situations in which individuals are daydreaming, letting deliberately their minds wander, purposely avoiding an assignment, or seeking mental respite from unpleasant circumstances. Additionally, there had been found reports of intentional MW in daily life activities (Seli et al., 2016) and in the laboratory (Forster & Lavie, 2009).

The *Stimulus-Independent Thought* (SIT) approach refers to ideas that come from changes within a person, rather than being directly caused by external stimulus (Maillet & Schacter, 2016). Certain researchers think MW should align with the stimulus-independent thought concept. Nevertheless, this definition may be too broad as it could incorporate task-related, goal-oriented thinking that is not usually considered MW. For instance, when individuals need to maintain information over time during a task, like a working memory task, they may still engage in stimulus-independent thought pertinent to the task at hand.

Lastly, there´s the *Stimulus-Independent Task-Unrelated Thought* (SITUT). According to this definition, MW is portrayed by thoughts that are both dependent on internal stimuli and unrelated to the ongoing task at hand (Stawarczyk et al., 2013). This means that for a thought to qualify as mind wandering under the SITUT definition, it must not be affected by current environmental cues and not serve any purpose related to the task being performed.

Overall, MW can be seen as a heterogeneous construct covering various experiences that can differ in terms of content, intention, task-relatedness, and response to external stimuli, among other factors (Seli, 2018). This diversity suggests that a single, classical definition may be insufficient to capture the complexity of mind wandering. In the present study, we will conceptualize MW as Task-Unrelated Thoughts (TUTs).

1.2 Why is it that our minds often wander?

Some researchers have tried to explain the causes of MW. However, the specific reasons for MW remain unknown. The current concerns hypothesis (Klinger et al., 1973) posits that MW occurs as a result of the allocation of attention to salient experiences or concerns. In such instances, the mind wanders during a task when participants find their personal concerns and goals to be more prioritized or fulfilling than the ongoing task (Randall et al., 2014).

The decoupling hypothesis tell us that when the beginning of a mental process isn’t directly linked to an external event, it can be considered decoupled. This view states that processes like executive control became active once self-generated thoughts becomes the target of attention and contribute to maintain the continuity of an internal track of thoughts instead of directly controlling the occurrence (Smallwood, 2013).

Meanwhile, the executive failure hypothesis (McVay et al., 2009; McVay & Kane, 2012) suggests that to maintain external focus, executive control must minimize internal and perceptual distractions. In this hypothesis, wandering thoughts are seen as a type of distraction, so when the system controlling attention fails, irrelevant internal thoughts can thrive, leading to mind-wandering (Smallwood, 2013).

The context regulation hypothesis also tries to explain MW phenomenon. This theory suggests that the mind wanders as a way of adapting to the context, that is, those who can regulate when and how they engage in MW according to the demands of their task do so as a reflection of a cognitive system that works in an adaptive manner (Smallwood & Andrews-Hanna, 2013). The mind tends to wander directing attention to self-generated thoughts when the task requires less attention or low stimulus (non-demanding), experiencing fewer costs (Baird et al., 2012). On the other side, when the situation demands more attention (demanding), individuals mind wandering less (Mason et al., 2007). In this model, MW is not seen as undesirable or a failure of attention, but a flexible adaptation.

Rummel and Boywitt (2014) addresses the cognitive flexibility hypothesis, especially in the context of how people adjust their mind wandering (TUTs) according to task demands. It suggests that the ability to shift attention of an ongoing task to internal thoughts is related to the cognitive flexibility of the individual. Cognitive flexibility concerns changing viewpoints or approaches to a problem, flexibly adjusting to new issues, guidelines or demands like switching between tasks (Diamond, 2013). They discover that individuals with high working memory capacity are more likely to be able to flexibly adjust their engagement in mind wandering when they don’t need highly involvement in the task at hand. Therefore, in this hypothesis, MW can be seen as a strategic adaptation when focusing on the task is not necessary.

More recently, the multi-faceted framework suggests that MW is a multifaceted process instead of a single phenomenon, that can be influenced by various factors depending on the context (motivation), the disposition (neuroticism, mindfulness) and cognitive processes (working memory, attention control)(Robison et al., 2020).

In conclusion, although each of these theories centers around distinct mechanisms, they all try to explain why MW happen.

1.3 How to measure MW

It´s possible to assess MW through subjective and objective procedures. The subjective procedures usually employ experience sampling that encompasses a range of methods used to collect information about participants' thoughts, feelings, and/or behaviours, on several occasions over time. One common approach to evaluating MW in adults and children is experience sampling via thought probes (Hasan et al., 2024). During a task, at random intervals, the participant is asked to report if their attention was on the task or if they were thinking about something else. Nonetheless, other methods provide experience sampling reports. For example, the Self-caught method (occurs when the participant is asked to spontaneously report when he is mind wandering), the Retrospective method (implies collecting data about MW thought questionnaires, in a way that doesn't affect the task), and the Open-ended methods (the participants are asked to describe in their own words what they experienced during the task)(Lopez et al., 2023).

The subjective assessment of mind wandering relies on self-reporting. Depending exclusively on introspection implies that research on MW should be supported with external measures to corroborate the validity of the results ensuring that they are not only influenced by limitations of self-reports (Schooler & Schreiber, 2004). Therefore, researchers have also relied on behavioural and neural markers of mind wandering to support subjective reports (Smallwood & Schooler, 2015). These objective procedures may include the detection of MW from the eye movements and pupillometry, with participants showing great pupil dilation, less fixations and more frequent eye blinks while mind wandering (Smilek et al., 2010).

Physiological features, such as skin conductance and heart rate, have also been utilized in certain studies aimed at detecting MW. For instance, the Affectiva Q wrist-mounted sensor (Blanchard et al., 2014) and Photoplethysmography (Pham & Wang, 2015) were used to record physiological activity during a task, obtaining a 22 percent mind wandering detection accuracy in adults.

Electrophysiological research on MW have predominantly utilized event-related potentials to measure brain activity. These studies used auditory and visual stimuli, in a diversity of tasks, including the Sustained Attention to Response Task (SART), visual search, detection tasks, among others. The most documented ERP components associated with mind wandering were the reductions in the amplitude of P1, N1 and P3. There was also a general tendency suggesting increased brain activity in lower frequency bands (delta, theta, and alpha) and decreased activity in beta band during MW (Kam et al., 2022).

Despite providing valuable insights that do not require participant self-reporting, studies that use instruments such as eye trackers and electroencephalograms are expensive and can only be used in laboratory contexts. More recently, Bosch and D'Mello (2021) tried to assess MW from facial features by recording videos of participants' faces while they watched a film. Participants presented more frequent eye blinking, fewer and longer gaze fixations, and more irregular saccades during periods when they reported being in mind wandering. It was also possible to find that certain specific facial expressions such as Facial Action Units (AUs) 23 (lip tightener) and 26 (jaw drop), an absence of facial muscle movement (neutral facial expressions), head nodding or tilting, and zoning out (seem to be staring blankly at the screen) were potential indicators of mind wandering.

Overall, regarding the most suitable method for evaluating MW, the literature underlies the importance of employing different procedures to ensure an accurate representation of MW that is not tied to a specific method.

1.4 Validity of self-reports

It's relevant to check if the self-reports and the instruments that assess MW are truly accurate. As stated by Schooler and Schreiber (2004), looking at the association between subjective reports and behavioral/physiologival methods is an important step to identify if participants self-reports reflect the truth. In adults, evidence from neuroimaging studies and behavioural research mention above supports the validity of self-report methods of MW (see Kam et al., 2022 for a summary). Another way to validate the subjective measures of mind wandering can be seen in studies that show more errors in task performance when the participant is mind wandering (Brosowsky et al., 2023).

Supporting the validity of self-report measures, studies have shown that children aged 8 and older know that when they are sitting without doing anything, they have some ideas and thoughts rather than an empty mind. As well as being able to describe what's on their minds, children can also identify when their mind wanders (Hasan et al., 2024, Ye et al., 2014, Zhang et al., 2015).

Additionally, frequency data obtained from experience sampling relate to retrospective reports on mind wandering in the daily lives of both adults and children, demonstrating agreement between these two modalities of self-report assessment (Keulers & Jonkman, 2019). It seems that the self-reports and the instruments can be trusted.

1.5 MW association with Cognitive Performance

Several studies have explored the relationship between MW and cognitive performance. It appears that mind wandering might affect cognitive function in both positive and negative ways. On one hand, it seems that MW per se is not an inadequate process but rather an essential phenomenon for human experience (Bonifacci et al., 2022). Stawarczyk et al. (2011) explore the impact of MW on the performance of the Sustained Attention to Response Task (SART) and discover that the content of most reported SITUTs centered around anticipating and planning for future events. Participants who focused on their personal goals before taking the SART showed an increased “prospective bias”. These findings suggest that MW plays a crucial role in looking ahead and planning for the future. Baird et al. (2012) looked at whether doing an undemanding task (which maximized MW), a demanding task, a rest period, or no break at all between creativity problems, affected performance on validated creativity problems. They observed that during an incubation phase, participating in undemanding work led to higher levels of creative solutions to problems compared to the demanding task. The task condition that was the least demanding also had the highest frequency of MW. Hence, the ideal settings for MW are also often those that promote new problem-solving approaches.

On the other hand, there are the costs of MW. Studies involving adult participants suggest that an increased frequency of MW is linked to poorer performance (Bonifacci et al., 2022). Regarding the findings about reading, Kopp and D’Mello (2016) conducted three experiments where participants were presented with a text to be read at their own pace (Self-paced Reading – condition 1). A distinct condition involved participants listening to an audio presentation of the materials without any visual text (Audio Only). A third condition displayed the text and audio narration of the text (Audio + Text). The audio-only condition produced higher levels of MW, that is, participants who listened to the material without any accompanying text were more likely to engage in task-unrelated thoughts. Self-paced reading condition and audio+text condition exhibited similar levels of mind wandering. However, in experiment 3, fast readers in the Self-paced reading condition tended to mind wander more than those in the audio+text condition.

Mind wandering also has negative impacts on list learning by disrupting encoding processes. Mind wandering has been shown to disrupt the encoding process, which is crucial for effective learning. When people let their minds wander trying to remember something like a list of words, their ability to classify and recall that information diminishes (Garlitch & Wahlheim, 2020). Two studies involving teenagers have also demonstrated the connection between MW and learning. According to research by Soemer et al. (2019), reading comprehension of 13- and 14-year-olds is negatively associated with retrospective reports of MW. Additionally, Mrazek et al. (2013) show that higher levels of task-unrelated thoughts were correlated with less comprehension in middle school and high school students.

Despite the large majority of studies about MW being made with adults, there are a few developmental studies assessing MW during childhood. Using the probe-caught method, Ye et al. (2014) observed that, in children aged 8 to 14, MW was linked to reduced performance on reaction time and n-back tasks, as is often observed in adult studies.

In the study by Cherry et al. (2022), the direct impact of mind wandering on memory retention in children was investigated for the first time. 97 children aged 6 to 11 years old participated in the listening activity, during which the frequency of MW was measured using probe thought. Participants then completed a memory retention test. The findings revealed that children reported mind wandering 25% of the time (very rarely reported intentional MW), and this frequency didn’t change with increasing age. There was also a solid negative relationship between MW and memory retention.

Hasan et al (2024) presented to one hundred children three activities focusing on different aspects of executive function that were successfully finished. Participants were occasionally asked during each task to indicate whether they were focused on the task or engaging in mind wandering. When studying the correlation between MW frequency and executive function across ages 8 to 12, they found that working memory capacity was negatively associated with mind wandering only in 12-year-olds (Hasan et al., 2024).

In general, it can be observed that there is a relationship between mind wandering and cognitive functioning, both in adults and children, although there are fewer studies that show this relationship in younger age groups.

1.6 Aim and hypotheses of this study

At school, there are several activities that involve the students to pay attention in classroom. In those moments, we often catch ourselves thinking about something else. In the same sense, excessive off-task thinking during reading has been found to diminish individuals' comprehension of the material (Smallwood, 2013). Learning relies on acquiring knowledge from the learning setting and integrating this fresh knowledge with prior understanding, and MW indicates an interference in this procedure. Despite its evident educational significance, few studies have attempted to investigate mind wandering in children (Cherry et al., 2023).

In the absence of compelling evidence substantiating the relation of mind wandering on children cognitive performance, this study aims to explore the possibility of assessing mind wandering in primary school children and to determine its association with cognitive performance. To do this, we will use the probe-caught method, the retrospective method, and one objective measure, the heart rate, to accurately evaluate MW in children.

A review of the literature suggests that mind wandering may occur in 20-33% of cases in children and is expected a negative correlation between mind wandering and cognitive performance. On the other hand, it is expected a positive relation between the measures of mind wandering via questionnaire and the measure of MW via experience sampling during the task, as well as a positive relation of these measures with heart rate.

2. Method

2.1 Participants

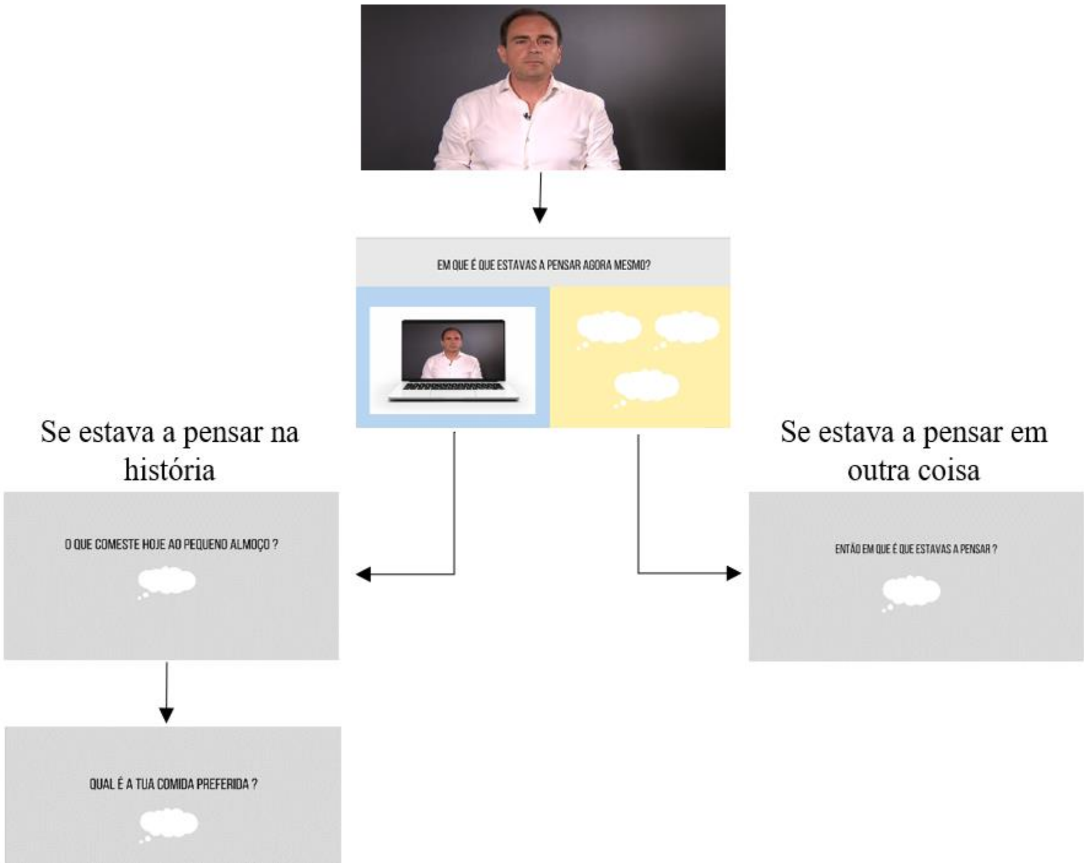
The original sample included 49 participants, but one was exclude because he didn’t complete all the tests. The final sample consisted of 3rd and 4th-grade students from a Portuguese primary school (28 female, 20 male), with an average age of 9,19 years (standard deviation = 0,891). To participate in the study, children had to fulfil the following inclusion criteria: age between 8 and 11 years old, be a fluent Portuguese speaker, and have normal or corrected vision and hearing. Participants were excluded if they had a history of developmental disorders and/or special educational needs.

2.2 Materials

2.2.1 Mind Wandering Task

The frequency of mind wandering was assessed using a probe-caught method (Cherry et al., 2022), adapted to Portuguese children (Campos, 2025). Participants watched and listened to a pre-recorded video of an actor narrating a story set in Ancient Egypt. The video recording was presented on a computer screen using PowerPoint and included six thought probes throughout the story. Each probe consisted of a first question asking if children were on-task or off-task (i.e., ‘‘What were you thinking about just now? The story or something else?”). When children reported that their attention was focused on the story, they were prompted to answer two simple questions (e.g., “what’s the name of your professor?”). Participants were asked two further questions about their thoughts if they reported thinking about something other than the story. To examine the intentionality of MW, participants were asked to reveal the topic of their thoughts (i.e., “Can you tell me what you were thinking about just now?”") and then prompt with the following question “Were you trying to think of [disclosed topic]?”

Figure 2.1 Example of MW Task – Probe 1



2.2.2 Memory Retention Task

Ten multiple-choice questions were used to test memory retention. All questions were about the story of Ancient Egypt presented in the MW task and were read out loud to participants. Each answer was scored as either correct (1) or incorrect (0).

2.2.3 Digit Span

The Digit Span test is a subtest of WISC-III (Wechsler, 2003), consisting of sequences of digits the participant must repeat after the examiner has read them. It consists of two parts: one where the subject must repeat the numbers in the order presented (Digits Span forward) and the other where they must repeat the sequence in reverse order (Digits Span Backward) (Stafford & Bennett, 2024). This subtest assesses working memory capacity, which is the ability to restrain and manipulate information for a short period (Diamond, 2013). Each item comprises of two trials, each containing the same number of digits. The test is suspended after failure on both trials of an item. Each trial is scored 1 if correct and the total score is converted into a standardized score. The results are distributed according to a mean value of 10 and a standard deviation of 3 (mean values between 8 and 12).

2.2.4 Verbal Fluency

The Verbal Fluency test (Coimbra Neuropsychological Assessment Battery – BANC) (Simões et al., 2016) assesses the individual's ability to generate words according to semantic and phonemic categories. In semantic verbal fluency, participants are asked to say aloud as many animal names, boy and girl names, and names of things to eat as possible within 60 seconds each. To assess phonemic verbal fluency, participants are asked to generate as many words as possible that begin with the letters P (item 1), M (item 2), and R (item 3), for 60 seconds each (phonemic verbal fluency)(Moura et al., 2018).

Any repetitions, errors, or nonsense words are noted for each item, and the words are written as the child says them. The score consists of the number of the words generated in the three trials and then are converted into standardized scores.

2.2.5 Trail

The Trail Subtest is a component of the Coimbra Neuropsychological Assessment Battery – BANC (Simões et al., 2016) and assesses visual search, psychomotor speed, and the ability to focus, switch, and divide attention (Moura et al., 2018). The test comprised two sections. Part A consists of connecting circles from 1 to 25, which are scattered randomly on a sheet of paper, weaving a line without lifting the pencil from the sheet (1 to 2, 2 to 3, 3 to 4, etc.). In Part B, the participant is required to connect 25 circles with letters and numbers, through a pencil line. The sequence begins with the number 1 and continues until reaching 13, interspersing the letters from A to M (1 to A, A to 2, 2 to B, B to 3...). For both parts, the scores correspond to participants' response time, expressed in seconds. The interpretation of the results is carried out through standardized values.

2.2.6 The Raven's Coloured Progressive Matrices Test (CPM) - parallel version/form (CPM-P)

The CPM-P (Raven et al., 2003) is a non-verbal test that assesses general intelligence. It is standardized for Portuguese children aged 5-12 years (Ferreira, 2009), and comprises 36 items, categorized into three sets of 12 items (Set A, Set Ab, and Set B). The items are brightly coloured to maintain children's attention and are presented with increasing difficulty within each group (Carvalho et al., 2020).

Each item is formed by a matrix of abstract geometric figures with a missing element that must be filled by one of the six possible choices below the matrix (Brites, 2009). One point is awarded if the participant answered correctly, and the cumulative score is transformed into a standardized score.

2.2.7 Stroop fruits Test

The Stroop Color and Word Test (Stroop, 1935) is a neuropsychological test that measures the ability to inhibit cognitive interference, which occurs when one aspect of a stimulus affects how another aspect of the same stimulus is processed (Scarpina & Tagini, 2017).

For the present study, a Stroop task with fruits, based on the original Stroop Colour and Word Test, was created (see annex A), eliminating the word content. The first subtest (Stroop A) assesses the ability to recognize colours and presents a series of 24 coloured squares in green, red or yellow, randomly arranged. Children needed to name, in the right order, the colours of the squares as quickly as they could. Stroop B consists of 24 fruits (kiwis, strawberries, and bananas) in their original colours and participants had to name the colour of the fruits. In the Stroop C task, the same 24 fruits (kiwis, strawberries, and bananas) were shown in black and white. Children were asked to identify and name the original colour of each fruit (green, red or yellow), measuring their prototypical knowledge of colour-fruits associations (Ziane et al., 2024). The last subtest (Stroop D) shows 24 fruits with colours that did not correspond to those expected (e.g., a red kiwi or a yellow strawberry). Children were required to name the colour of each fruit in real life, inhibiting the automatic response. Each subtest was timed in seconds, and errors were noted. The results are interpreted taking into account the number of errors and the participant's response time.

2.2.8 Mind Wandering Questionnaire

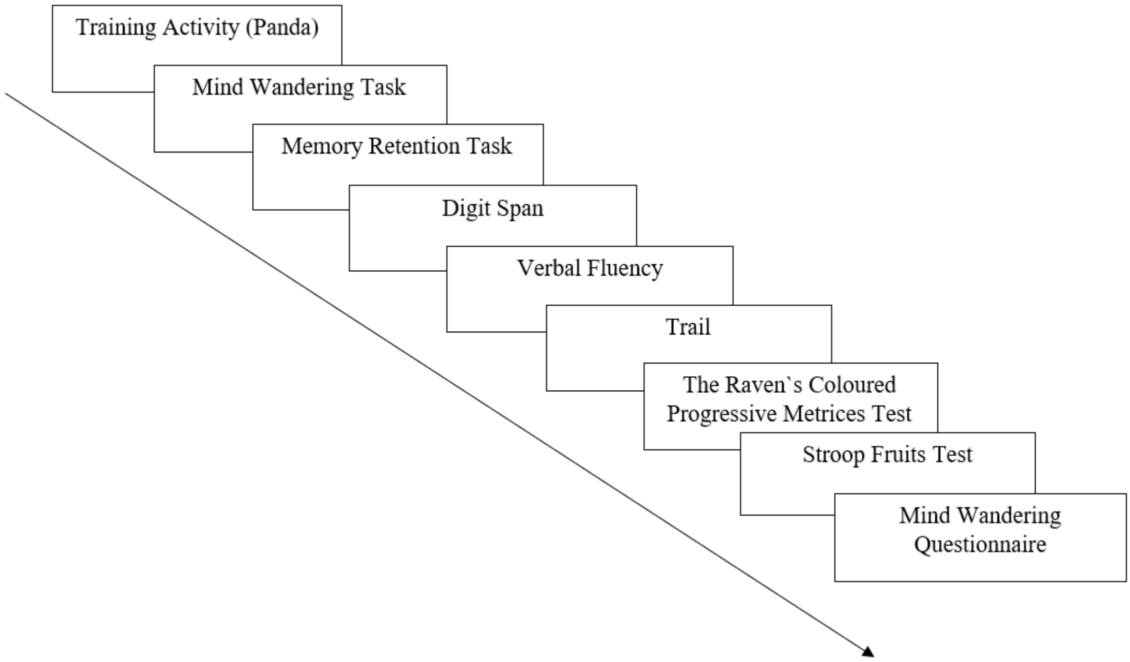
The Mind-wandering frequency in daily life was assessed with The Mind Wandering Questionnaire (MWQ)(Mrazek et al., 2013). The questionnaire is a 5-item self-report scale, with items rated on a 6-point scale ranging from 1 (almost never) to 6 (almost always). In this study, a Portuguese version of the MWQ was administered verbally to the participants (Gonçalves et al.,2020). However, like Hasan and colleagues (2024), the final question was modified to be more suitable for children (‘‘I mind wander during lectures or presentations” was changed to ‘‘I mind wander when my teacher is teaching in class or when my classmates are presenting”).

2.3 Procedure

The study took place in a primary school in Tavira, and consent for the children to participate in the study was given by their parents after been informed about the study's goals and procedures.

Children were evaluated in one session during school hours. First, the session began with a training activity, designed to explain to children what MW is and how to identify it. This activity was displayed in PowerPoint and showed a Panda cartoon. Participants saw the Panda listening to a story about penguins that had thought probes. Children had to report whether Panda was "thinking about the story" or "thinking about something else". When Panda experienced off-task thoughts, the children heard an audio elucidating the genesis of Panda's off-task thought, distinguishing between intentional and nonintentional occurrences. Next, they were required to assess whether Panda had been deliberately contemplating the content of the off task thought or not. Children could advance to the MW Task if they answered correctly the questions about Panda's thoughts. In the MW Task, children were told they would listen to a story and, likewise Panda, they would sometimes be questioned about their thoughts during the story. Participants were presented with a narrative about Ancient Egypt, which contained six thought probes made by the experimenter. During the MW Task, children's faces were recorded with the computer webcam, and their heart rates were also measured by a Heart Rate monitor armband HRB 500 (Kalenji). In this study, face video records were not analysed. When the story ended, the children took a memory test based on the story. Then the cognitive assessment was performed (digit span, verbal fluency, trail making test, stroop and the Raven's Coloured Progressive Matrices Test), and finally children were questioned about how often their minds wander in daily life, through a MW questionnaire.

Figure 2.2 Sequence of the experimental procedure



3. Results

All statistical analyses were carried out using the Statistical Package for the Social Sciences (SPSS).

On average, children reported Mind Wandering 16.32% of the time during the task (95% confidence interval: [11.0%, 21.6%]) and the task unrelated thoughts (TUTs) were mostly reported as unintentional (80,8%).

Considering the levels of MW in each probe (Table 3.1), the percentage of participants reporting MW seems to oscillate throughout the task (between 14,6% and 20,8%), except for the third probe where only three participants (6,3%) reported TUTs.

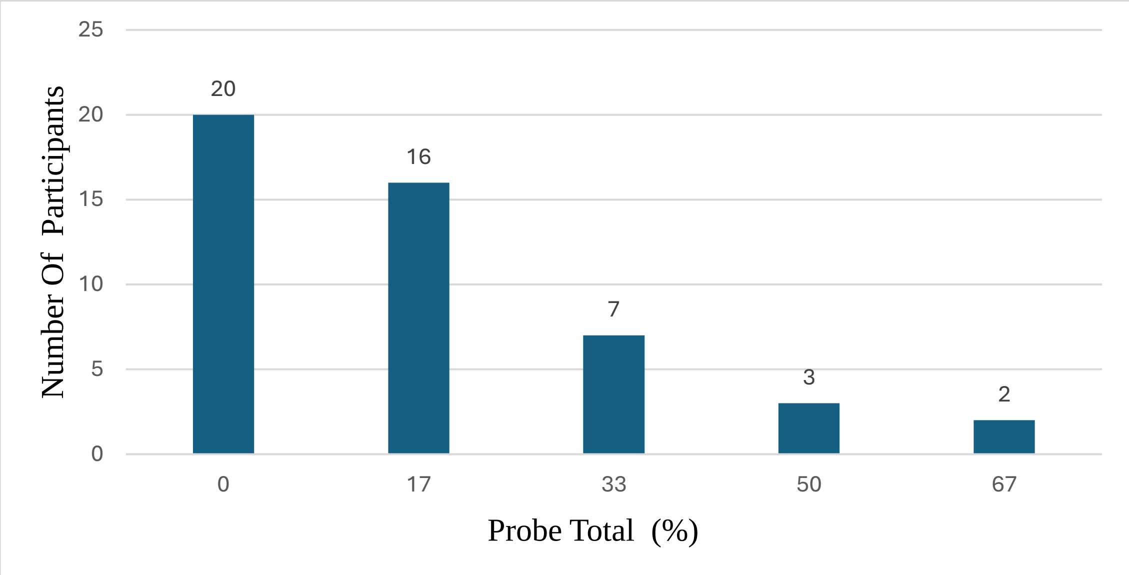
Table 3.1 MW reported on each probe

	MW Total	MW Unintentional %
Probe 1	7 (14,6%)	85,7%
Probe 2	10 (20,8%)	90%
Probe 3	3 (6,3%)	66,6%
Probe 4	10 (20,8%)	80%
Probe 5	7 (14,6%)	57,1%
Probe 6	10 (20,8%)	90%

Note. MW Total: MW (intentional and unintentional) frequency/percentage reported in the MW Task; MW Unintentional: Unintentional MW percentage reported in the MW Task.

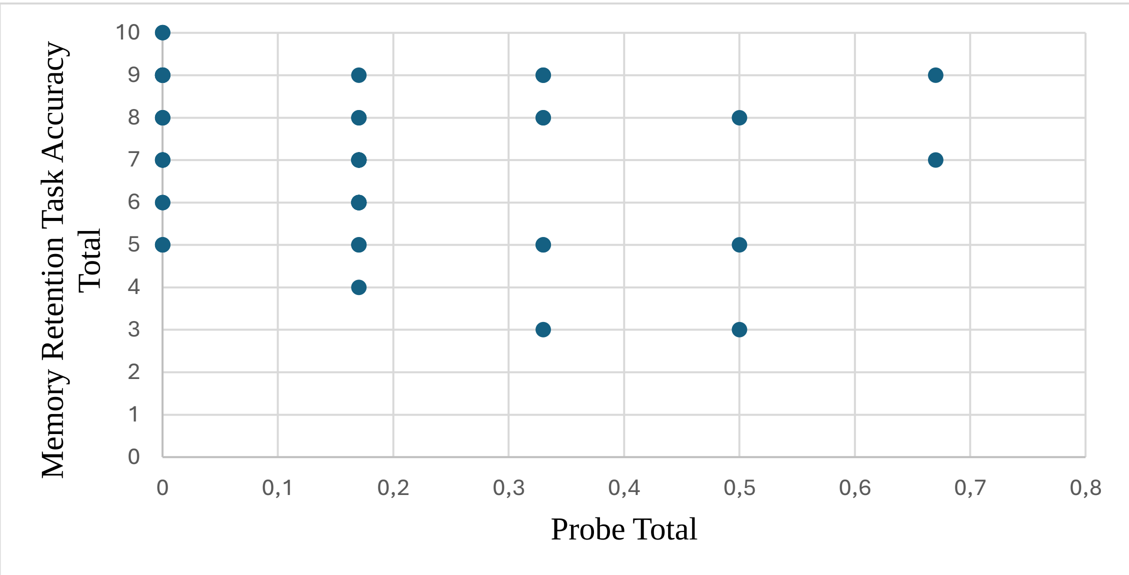
However, its's noticeable that twenty participants out of the forty-eight reported not being Mind Wandering at all during the task (Graph 3.1).

Graph 3.1 Percentage of MW reported in the MW Task



The Graph 3.2 shows the total number of correct answers in the Memory Retention Task and the frequency of MW in MW Task (Probe Total). It's possible to observe that two participants report been engaged in task unrelated thoughts (TUTs) more than sixty percent of the time during the MW Task. Nevertheless, there was no negative effect on the Memory Retention Task as they got more than half of the ten questions right.

Graph 3.2 Memory Retention Task and MW Task



Was found a negative relationship between the self-reports of MW during the probe one and the questions seven (r = - .348, p = .05) and eight (r = - .331, p = .05). This suggests that an accurate response corresponds to no MW reported in the probe. There is also a negative correlation between the fourth probe and the first question (*r* = - .318, *p* = .05); and a positive relation between the probe 3 and the question 3 (*r* = .365, *p* = .05). However, the information we need to answer correctly these questions doesn't match the text that was narrated before the probe in question. For example, the details for answer accurate the first and the seventh questions was in the narration just before the probe three; the relevant information about the questions number three and eight concerns to what was said before the probe 3 and 5, respectively.

Table 3.2 Correlation between Memory Retention Task questions and MW Task probes

	MRT1	MRT2	MRT3	MRT4	MRT5	MRT6	MRT7	MRT8	MRT9	MRT 10
Probe 1	0,024	-0,014	-0,042	0,185	0,102	0,125	0,005	0,085	-0,014	-0,094
Probe 2	0,014	0,082	-0,145	-0,184	-0,059	-0,031	-0,348*	-0,331*	0,082	-0,043
Probe 3	0,174	0,157	0,365*	-0,115	-0,050	0,078	-0,213	-0,269	0,157	-0,108
Probe 4	-0,318*	-0,149	-0,145	0,092	-0,178	0,155	-0,122	-0,086	-0,149	-0,146
Probe 5	0,024	0,119	-0,042	0,026	0,102	0,125	-0,124	-0,056	0,119	0,025
Probe 6	0,014	-0,265	0,073	-0,229	-0,059	-0,217	-0,122	-0,086	-0,265	-0,043

Note. MRT 1: Answer to question one of the Memory retention task; MRT 2: Answer to question two of the Memory retention task; MRT 3: Answer to question three of the Memory retention task; MRT 4: Answer to question four of the Memory retention task; MRT 5: Answer to question five of the Memory retention task; MRT 6: Answer to question six of the Memory retention task. * $p < .05$

No relationship was found between the report of mind wandering during the task and the measure of heart rate.

Table 3.3 Correlations between MW and Heart Rate

	Probe 1	Probe 2	Probe 3	Probe 4	Probe 5	Probe 6
Heart Rate 1	-0,215					
Heart Rate 2		0,145				
Heart Rate 3			-0,066			
Heart Rate 4				0,060		
Heart Rate 5					-0,180	
Heart Rate 6						-0,064

Note. Heart Rate 1: Heart Rate measured ten seconds before probe one; Heart Rate 2: Heart Rate measured ten seconds before probe two; Heart Rate 3: Heart Rate measured ten seconds before probe three; Heart Rate 4: Heart Rate measured ten seconds before probe four; Heart Rate 5: Heart Rate measured ten seconds before probe five; Heart Rate 6: Heart Rate measured ten seconds before probe six. ** $p < .01$

The Mind Wandering Questionnaire (MWQ) total score showed a satisfactory reliability (Cronbach's *alpha* = 0,602) and its distribution was grossly symmetric, ranging from 5 to 28, with an average of 13.40 (SD = 4,49).

The correlation between the MW Task score and the MWQ was moderate and positive ($r = .398$, $p = .001$). This positive association suggests that people who mind-wander more when they're engaged in story listening task were also those who have more mind-wandering during their daily life. Age and gender are not reliably related to the MW measured by the probe task (Table 3.4).

Table 3.4 Correlations between MW, Gender, Age (*p* value in parenthesis)

	Probe_Total	MWQ_Total
MWQ_Total	0,398**	
Age	0,221	0,130
Gender	-0,100	-0,218

Note. Probe_Total: MW Frequency in the MW Task; MWQ_Total: The Mind Wandering Questionnaire. ** $p < .001$

The descriptive analysis of the cognitive tests comprises the mean and standard deviation (Table 3.5).

Table 3.5 Means, and standard deviations of the results obtained in the cognitive tests

	Mean	Std. Deviation
DS ss	9,25	2,392
VF semantic ss	10,46	2,989
VF phonemic ss	8,48	3,519
TMT A ss	12,33	2,495
TMT B ss	9,15	3,644
TMT BminusA ss	7,94	3,411
CPM perc	63,13	23,826
StroopA T	18,23	3,915
StroopB T	19,40	4,423
StroopC T	19,90	5,337
StroopD T	26,88	6,747

Note. DS ss: Digit Span Task standardized score; VF Semantic ss: Semantic Verbal Fluency Task standardized score; VF Phonemic ss: Phonemic Verbal Fluency Task standardized score; TMT A ss: Trail Making Test Part A standardized score; TMT B ss: Trail Making Test Part B standardized score; TMT BminusA ss: Trail Making Test Part B minus Part A standardized score; CPM perc: The Raven’s Coloured Progressive Matrices Test percentile; StroopA T: Stroop Fruit Test Part A response time; StroopB T: Stroop Fruit Test Part B response time; StroopC T: Stroop Fruit Test Part C response time; StroopD T: Stroop Fruit Test Part D response time;

The outcomes of the cognitive tests, The Mind Wandering Questionnaire (MWQ), and the MW Task were correlated using Pearson’s correlation coefficients (Table 3.6). There were no significant associations between the cognitive tests and neither one of the MW self-report measures.

Table 3.6 Correlations between MW, Memory Retention Task and Cognitive Tests (*p* value in parenthesis)

	Probe_Total	MWQ_Total
DS_ss	0,018	0,154
VF_Semantic_ss	-0,146	-0,087
VF_Phonemic_ss	0,003	-0,121
TMT_A_ss	-0,106	-0,052
TMT_B_ss	-0,068	0,043
TMT_BminusA_ss	-0,017	0,103
CPM_perc	-0,196	-0,086
StroopA_T	-0,043	0,089
StroopB_T	0,024	0,226
StroopC_T	-0,105	0,104
StroopD_T	0,086	0,100
Stroop_Interf	0,091	-0,062
Stroop_Interf__pp	0,099	-0,181
MRT_acc_total	0,208	-0,110

Note. Probe_Total: MW Frequency in the MW Task; MWQ_Total: The Mind Wandering Questionnaire; DS_ss: Digit Span Task standardized score; VF_Semantic_ss: Semantic Verbal Fluency Task standardized score; VF_Phonemic_ss: Phonemic Verbal Fluency Task standardized score; TMT_A_ss: Trail Making Test Part A standardized score; TMT_B_ss: Trail Making Test Part B standardized score; TMT_BminusA_ss: Trail Making Test Part B minus Part A standardized score; CPM_perc: The Raven's Coloured Progressive Matrices Test percentile; StroopA_T: Stroop Fruit Test Part A response time; StroopB_T: Stroop Fruit Test Part B response time; StroopC_T: Stroop Fruit Test Part C response time; StroopD_T: Stroop Fruit Test Part D response time; Stroop_Interf: Stroop Fruit Test Part Part D response time minus Part B response time; MRT_acc_total: Composite measure of the memory retention task. * $p < .05$

4. Discussion

This study aimed to investigate the possibility of assessing Mind Wandering in primary school Portuguese children and to determine its association with their cognitive performance. To attend this goal, a sample of 48 typically developing children, aged between 8 to 11 years, performed a story visual-listening task while their thoughts were sampled using a probe caught procedure to assess the occurrence of MW.

We found that throughout an ongoing task, children reported TUTs approximately 16 % of the time (95% confidence interval ranging between 11% as 22%). This value is below the MW's frequency reported by previous studies with school-aged children (20–33%; Cherry et al., 2022; Keulers & Jonkman, 2019; Zhang et al., 2015). This level of TUTs reports differs from those obtained by Cherry et al. 2022, who assessed MW in children 6 to 11 years old by applying a similar MW Task, where children listened to a story set in Ancient Egypt that contained six probe thoughts. Their results showed that children report engaging in TUTs 25% of the time. However, the MW task used by Cherry et al. was a listening-only task where children listen to a pre-recorded audio. On the contrary, our Portuguese participants listened and watched a pre-recorded video of an actor narrating the story about Egypt in Portuguese. This modification may have contributed to our smaller frequency of Mind wandering. This interpretation can be corroborated by a study done by Kopp & D'Mello (2016), in which they observed that listening to a text, comparing to reading it or listening and reading the text simultaneously, produced higher levels of MW. These results suggest that participants who listen to the audio material without any visual accompanying text were more likely to engage in task-unrelated thoughts. The fact that the present study used a visual and listening stimuli may have led to higher attention to the task, resulting in lower occurrence of MW. It was also observed that the percentage of participants reporting MW seems to oscillate throughout the task (between 14,6% and 20,8%), except for the third probe where only three participants (6,3%) reported TUTs. This might have happened because the segment of the story told before the third interruption (probe-thought) was shorter (1 min 20 seg) than the rest of segments before the other interruptions (approximately 2 minutes).

However, there wasn't any significant association between MW measures and cognitive performance, heart rate, age, or gender. Regarding the finding about Memory retention task, stand out two participants that reported been engaged in task unrelated thoughts (TUTs) more than sixty percent of the time during the MW Task and got more than half of the ten questions right. This could have happened because they have a good executive control. In line with the context regulation hypothesis (Smallwood & Andrews-Hanna, 2013), people can adjust and directing attention to self-generated thoughts when the task requires less attention or has low stimulus (non-demanding), experiencing few costs on the task (Baird et al., 2012). It seems that the resources that aren't being used in the task will be utilised to engaged in MW and doesn't have costs because those resources aren't need for the task.

There was also no association between the measures of mind wandering and heart rate, which isn't in harmony with a study, with 24 participants, that discovered that MW events might be predicted using heart rates. They used a technique based on photoplethysmography sensing, AttentiveLearner, that captures participants' heart rates during learning by monitoring the fingertip transparency changes captured by the back camera (Pham & Wang, 2015). We chose to use a Heart Rate monitor armband HRB 500 (Kalenji) because it's easy to transport, intuitive to use, and an economical option. However, may not be the most accurate instrument to measure and synchronize the heart rate with MW probe-reports in children.

Our results suggest a positive correlation between the measure of MW during an ongoing task and the measure of MW in daily life. In other words, it seems that people who mind-wander less when they're engaged in a task are also the ones who have less mind-wandering during their day. This is in line with previous studies (Hasan et al., 2024). They explored the link between MW and executive functions and assessed mind wandering via questionnaire as well as experience sampling during the task, discovering a positive correlation between these two measures. Therefore, the results of the questionnaire appear to corroborate the experience sampling reports, concluding that people that mind wandering more during tasks also mind wandering more in their day.

Contrary to our prediction, there wasn't any significant correlation between MW measures and cognitive performance. This goes against the studies carried out with children that indicate that mind wandering is associated with poorer working memory (Ye et al., 2014), sustained attention (Zhang et al., 2015), executive function (Keulers & Jonkman, 2019), memory retention (Cherry et al., 2022) and memory recall (Cherry et al., 2024). The changes that we did to the MW task (mentioned above) may have led to fewer self-reports of MW, resulting in an absence of significant association between the MW measures and cognitive performance of our children. Something else that may have affected these results obtained is the size of the sample and/or low sensibility of tasks such as Stroop fruits test.

Overall, the present study contains some limitations. Apart from the methodological differences mentioned above in the discussion, the small sample size might have affected the results. Another weakness is that some cognitive assessment tests lack standardised scores, making it hard to establish if the effects identified are due to atypical or normative performance in this sample participants.

In conclusion, although studies about mind wandering have grown in recent years, there is still a need to develop research to understand this human phenomenon, and especially its development in children. It would be important for future studies to design methods that accurately assess MW and clarify the factors associated with having more MW. This way it will be possible to maximize or reduce mind wandering depending on the situation that we are in and according to our objectives.

5. Bibliography

Baird, B., Smallwood, J., Mrazek, M. D., Kam, J. W. Y., Franklin, M. S., & Schooler, J. W. (2012). Inspired by Distraction: Mind Wandering Facilitates Creative Incubation. *Psychological Science*, *23*(10), 1117–1122. https://doi.org/10.1177/0956797612446024

Blanchard, N., Bixler, R., Joyce, T., & D'Mello, S. (2014). Automated physiological-based detection of mind wandering during learning. In *Intelligent Tutoring Systems: 12th International Conference, ITS 2014, Honolulu, HI, USA, June 5-9, 2014. Proceedings 12* (pp. 55-60). Springer International Publishing.

Bonifacci, P., Colombini, E., Marzocchi, M., Tobia, V., & Desideri, L. (2022). Text-to-speech applications to reduce mind wandering in students with dyslexia. *Journal of Computer Assisted Learning*, *38*(2), 440–454. https://doi.org/10.1111/jcal.12624

Bosch, N., & D'Mello, S. K. (2021). Automatic Detection of Mind Wandering from Video in the Lab and in the Classroom. *IEEE Transactions on Affective Computing*, *12*(4), 974–988. https://doi.org/10.1109/TAFFC.2019.2908837

Brites, S. M. D. R. (2009). *Teste das Matrizes Progressivas Coloridas de Raven: Estudos psicométricos e normativos com crianças dos 4 aos 6 anos* (Master's thesis).Brosowsky, N. P., DeGutis, J., Esterman, M., Smilek, D., & Seli, P. (2023). Mind Wandering, Motivation, and Task Performance Over Time: Evidence That Motivation Insulates People From the Negative Effects of Mind Wandering. *Psychology of Consciousness: Theory Research, and Practice*, *10*(4), 475–486. https://doi.org/10.1037/cns0000263

Brosowsky, N. P., DeGutis, J., Esterman, M., Smilek, D., & Seli, P. (2023). Mind Wandering, Motivation, and Task Performance Over Time: Evidence That Motivation Insulates People From the Negative Effects of Mind Wandering. *Psychology of Consciousness: Theory Research, and Practice*, *10*(4), 475–486. https://doi.org/10.1037/cns0000263

Carvalho, I. P., Costa, A., Silva, S., Moreira, B., Almeida, A., Moreira-Rosário, A., Guerra, A., Peixoto, B., Delerue-Matos, C., Sintra, D., Pestana, D., Pinto, E., Mendes, F. de C., Martins, I., Leite, J. C., Caldas, J. C., Fontoura, M., Maia, M. L., Queirós, P., … Calhau, C. (2020). Children's performance on Raven's Coloured progressive matrices in Portugal: The Flynn effect. *Intelligence*, *82*(February), 101485. https://doi.org/10.1016/j.intell.2020.101485

Campos, C. (2025). Avaliação da divagação mental em crianças pré-escolares [Unpublished master's thesis] Universidade do Algarve

Champaign, J., & McCalla, G. (2015). AttentiveLearner: Improving Mobile MOOC Learning via Implicit Heart Rate Tracking. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *9112*, 883. https://doi.org/10.1007/978-3-319-19773-9

Cherry, J., McCormack, T., & Graham, A. J. (2022). The link between mind wandering and learning in children. *Journal of Experimental Child Psychology*, *217*, 105367. https://doi.org/10.1016/j.jecp.2021.105367

Cherry, J., McCormack, T., & Graham, A. J. (2023). Listen up, kids! How mind wandering affects immediate and delayed memory in children. *Memory and Cognition*. https://doi.org/10.3758/S13421-023-01509-0

Cherry, J., McCormack, T., & Graham, A. J. (2024). Listen up, kids! How mind wandering affects immediate and delayed memory in children. *Memory and Cognition*, *52*(4), 909–925. https://doi.org/10.3758/s13421-023-01509-0

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Ferreira, C. (2009). Manual RCPM-P, Matrizes Progressivas de Raven—Escala Colorida (Versão Paralela).

Forster, S., & Lavie, N. (2009). Harnessing the wandering mind: The role of perceptual load. *Cognition*, *111*(3), 345–355. https://doi.org/10.1016/j.cognition.2009.02.006

Frick, M. A., Asherson, P., & Brocki, K. C. (2020). Mind-wandering in children with and without ADHD. *British Journal of Clinical Psychology*, *59*(2), 208–223. https://doi.org/10.1111/bjc.12241

Garlitch, S. M., & Wahlheim, C. N. (2020). The role of attentional fluctuation during study in recollecting episodic changes at test. *Memory and Cognition*, *48*(5), 800–814. https://doi.org/10.3758/s13421-020-01018-4

Hasan, F., Hart, C. M., Graham, S. A., & Kam, J. W. Y. (2024). Inside a child's mind: The relations between mind wandering and executive function across 8- to 12-year-olds. *Journal of Experimental Child Psychology*, *240*, 105832. https://doi.org/10.1016/j.jecp.2023.105832

Kam, J. W. Y., Rahnuma, T., Park, Y. E., & Hart, C. M. (2022). Electrophysiological markers of mind wandering: A systematic review. *NeuroImage*, *258*, 119372. https://doi.org/10.1016/J.NEUROIMAGE.2022.119372

Kane, M. J., Gross, G. M., Chun, C. A., Smeekens, B. A., Meier, M. E., Silvia, P. J., & Kwapil, T. R. (2017). For Whom the Mind Wanders, and When, Varies Across Laboratory and Daily-Life Settings. *Psychological Science*, *28*(9), 1271–1289. https://doi.org/10.1177/0956797617706086

Keulers, E. H. H., & Jonkman, L. M. (2019a). Mind wandering in children: Examining task-unrelated thoughts in computerized tasks and a classroom lesson, and the association with different executive functions. *Journal of Experimental Child Psychology*, *179*, 276–290. https://doi.org/10.1016/j.jecp.2018.11.013

Keulers, E. H. H., & Jonkman, L. M. (2019b). Mind wandering in children: Examining task-unrelated thoughts in computerized tasks and a classroom lesson, and the association with different executive functions. *Journal of Experimental Child Psychology*, *179*, 276–290. https://doi.org/10.1016/J.JECP.2018.11.013

Klinger, E., Gregoire, K. C., & Barta, S. G. (1973). Physiological Correlates of Mental Activity: Eye Movements, Alpha, and Heart Rate During Imagining, Suppression, Concentration, Search, and Choice. In *Psychophysiology* (Vol. 10, Issue 5, pp. 471–477). https://doi.org/10.1111/j.1469-8986.1973.tb00534.x

Kopp, K., & D'Mello, S. (2016). The Impact of Modality on Mind Wandering during Comprehension. *Applied Cognitive Psychology*, *30*(1), 29–40.

https://doi.org/10.1002/acp.3163

Lopez, A., Caffò, A. O., Tinella, L., & Bosco, A. (2023). The Four Factors of Mind Wandering Questionnaire: Content, Construct, and Clinical Validity. *Assessment*, *30*(2), 433–447. https://doi.org/10.1177/10731911211058688

Maillet, D., & Schacter, D. L. (2016). When the Mind Wanders : Distinguishing Stimulus-Dependent From Stimulus-Independent Thoughts During Incidental Encoding in Young and Older Adults. *31*(4), 370–379.

Mason, M. F., Norton, M. I., Van Horn, J. D., Wegner, D. M., Grafton, S. T., & Macrae, C. N. (2007). Wandering minds: The default network and stimulus-independent thought. *Science*, *315*(5810), 393–395. https://doi.org/10.1126/science.1131295

McVay, J. C., & Kane, M. J. (2012). Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. *Journal of Experimental Psychology: General*, *141*(2), 302–320. https://doi.org/10.1037/a0025250

McVay, J. C., Kane, M. J., & Kwapil, T. R. (2009). Tracking the train of thought from the laboratory into everyday life: An experience-sampling study of mind wandering across controlled and ecological contexts. *Psychonomic Bulletin and Review*, *16*(5), 857–863. https://doi.org/10.3758/PBR.16.5.857

Mooneyham, B. W., & Schooler, J. W. (2013). The costs and benefits of mind-wandering: A review. *Canadian Journal of Experimental Psychology*, *67*(1), 11–18. https://doi.org/10.1037/a0031569

Moura, O., Albuquerque, C. P., Salomé Pinho, M., Vilar, M., Filipa Lopes, A., Alberto, I., Pereira, M., Seabra-Santos, M. J., & Simões, M. R. (2018). Factor structure and measurement invariance of the coimbra neuropsychological assessment battery (BANC). *Archives of Clinical Neuropsychology*, *33*(1), 66–78. https://doi.org/10.1093/arclin/acx052

Mrazek, M. D., Phillips, D. T., Franklin, M. S., Broadway, J. M., & Schooler, J. W. (2013). Young and restless: Validation of the Mind-Wandering Questionnaire (MWQ) reveals disruptive impact of mind-wandering for youth. *Frontiers in Psychology*, *4*(AUG), 57268. https://doi.org/10.3389/FPSYG.2013.00560/BIBTEX

Murray, S., & Krasich, K. (2022). Can the mind wander intentionally? *Mind and Language*, *37*(3), 432–443. https://doi.org/10.1111/mila.12332

Peterson, D. J., & Wissman, K. (2020). Using tests to reduce mind-wandering during learning review. *Memory*, *28*(4), 582–587. https://doi.org/10.1080/09658211.2020.1748657

Pham, P., & Wang, J. (2015). AttentiveLearner: Improving Mobile MOOC Learning via Implicit Heart Rate Tracking. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *9112*, 883. https://doi.org/10.1007/978-3-319-19773-9

Randall, J. G., Oswald, F. L., & Beier, M. E. (2014). Mind-wandering, cognition, and performance: a theory-driven meta-analysis of attention regulation. *Psychological Bulletin*, *140*(6), 1411–1431. https://doi.org/10.1037/a0037428

Raven, J. (2003). Raven progressive matrices. In *Handbook of nonverbal assessment* (pp.

223-237). Boston, MA: Springer US.

Robison, M. K., Miller, A. L., & Unsworth, N. (2020). A multi-faceted approach to understanding individual differences in mind-wandering. *Cognition*, *198*(February 2019). https://doi.org/10.1016/j.cognition.2019.104078

Rummel, J., & Boywitt, C. D. (2014). Controlling the stream of thought: Working memory capacity predicts adjustment of mind-wandering to situational demands. *Psychonomic Bulletin and Review*, *21*(5), 1309–1315. https://doi.org/10.3758/s13423-013-0580-3

Scarpina, F., & Tagini, S. (2017). The stroop color and word test. *Frontiers in Psychology*,*8*(APR), 241674. https://doi.org/10.3389/FPSYG.2017.00557/BIBTEX

Seli, P. (2018). Mind-Wandering As a Natural Kind. *Trends in Cognitive Sciences*, *22*(6), 479–490. https://doi.org/10.1016/j.tics.2018.03.010.Mind-wandering

Seli, Paul, Risko, E. F., & Smilek, D. (2016). On the Necessity of Distinguishing Between Unintentional and Intentional Mind Wandering. *Psychological Science*, *27*(5), 685–691. https://doi.org/10.1177/0956797616634068

Simões, M. R., Albuquerque, C. P., Pinho, M. S., Vilar, M., Pereira, M., Lopes, A. F., et al. (2016). Bateria de Avaliação Neuropsicológica de Coimbra (BANC) [Coimbra Neuropsychological Assessment Battery]. Lisboa: CEGOC-TEA.

Simonton, D. K. (2018). Spontaneity in evolution, learning, creativity, and free will: Spontaneous variation in four selectionist phenomena. *The Oxford Handbook of Spontaneous thought: mind-wandering, creativity, and dreaming*, 113-122.

Smallwood, J. (2013). Distinguishing How From Why the Mind Wanders : *Psychological Bulletin*, *139*(3), 519–535. https://doi.org/10.1037/a0O30010

Smallwood, J., & Andrews-Hanna, J. (2013). Not all minds that wander are lost: The importance of a balanced perspective on the mind-wandering state. *Frontiers in Psychology*, *4*(AUG), 1–6. https://doi.org/10.3389/fpsyg.2013.00441

Smallwood, J., & Schooler, J. W. (2006). The restless mind. *Psychological Bulletin*, *132*(6), 946–958. https://doi.org/10.1037/0033-2909.132.6.946

Smallwood, J., & Schooler, J. W. (2015). The science of mind wandering: Empirically navigating the stream of consciousness. *Annual Review of Psychology*, *66*, 487–518. https://doi.org/10.1146/annurev-psych-010814-015331

Smilek, D., Carriere, J. S. A., & Cheyne, J. A. (2010). Out of mind, out of sight: eye blinking as indicator and embodiment of mind wandering. *Psychological Science : A Journal of the American Psychological Society / APS*, *21*(6), 786–789. https://doi.org/10.1177/0956797610368063

Soemer, A., Idsardi, H. M., Minnaert, A., & Schiefele, U. (2019). Mind wandering and reading comprehension in secondary school children. *Learning and Individual Differences*, *75*(January), 101778. https://doi.org/10.1016/j.lindif.2019.101778

Stawarczyk, D., Majerus, S., & Argembeau, A. D. (2013). Concern-induced negative affect is associated with the occurrence and content of mind-wandering. *Consciousness and Cognition*, *22*(2), 442–448.

https://doi.org/10.1016/j.concog.2013.01.012

Stawarczyk, D., Majerus, S., Maj, M., Van der Linden, M., & D'Argembeau, A. (2011). Mind-wandering: Phenomenology and function as assessed with a novel experience sampling method. *Acta Psychologica*, *136*(3), 370–381. https://doi.org/10.1016/j.actpsy.2011.01.002

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of experimental psychology*, *18*(6), 643.

Unsworth, N., & McMillan, B. D. (2013). Mind wandering and reading comprehension: Examining the roles of working memory capacity, interest, motivation, and topic experience. *Journal of Experimental Psychology: Learning Memory and Cognition*, *39*(3), 832–842. https://doi.org/10.1037/a0029669

Wechsler, D. (2003). Wechsler intelligence scale for children–Fourth Edition (WISC-IV).*(No Title)*.

Wong, A. Y., Smith, S. L., McGrath, C. A., Flynn, L. E., & Mills, C. (2022). Task-unrelated thought during educational activities: A meta-analysis of its occurrence and relationship with learning. *Contemporary Educational Psychology*, *71*, 102098. https://doi.org/10.1016/J.CEDPSYCH.2022.102098

Ye, Q., Song, X., Zhang, Y., & Wang, Q. (2014). Children's mental time travel during mind wandering. *Frontiers in Psychology*, *5*(AUG), 1–9. https://doi.org/10.3389/fpsyg.2014.00927

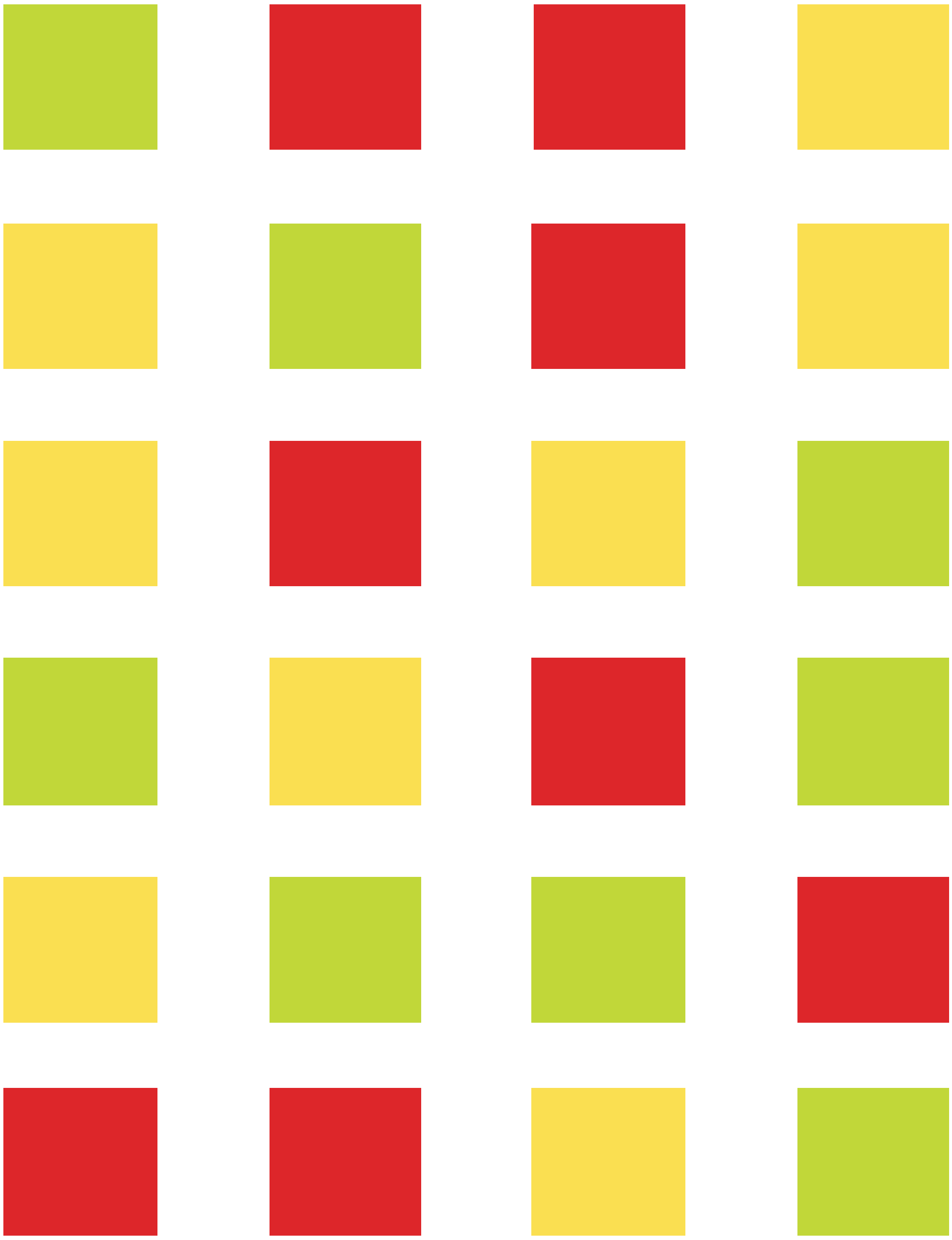
Zhang, Y., Song, X., Ye, Q., & Wang, Q. (2015). Children with positive attitudes towards mind-wandering provide invalid subjective reports of mind-wandering during an experimental task. *Consciousness and Cognition*, *35*, 136–142. https://doi.org/10.1016/j.concog.2015.05.006

Ziane, C., Wardak, & Hamed, B. (2024). Mind Wandering and Its Relationship With Sustained Attention and Executive Functions in Preschoolers. *PsyArXiv*, 1–42. https://europepmc.org/article/ppr/ppr786873

Annex A Stroop fruits Test

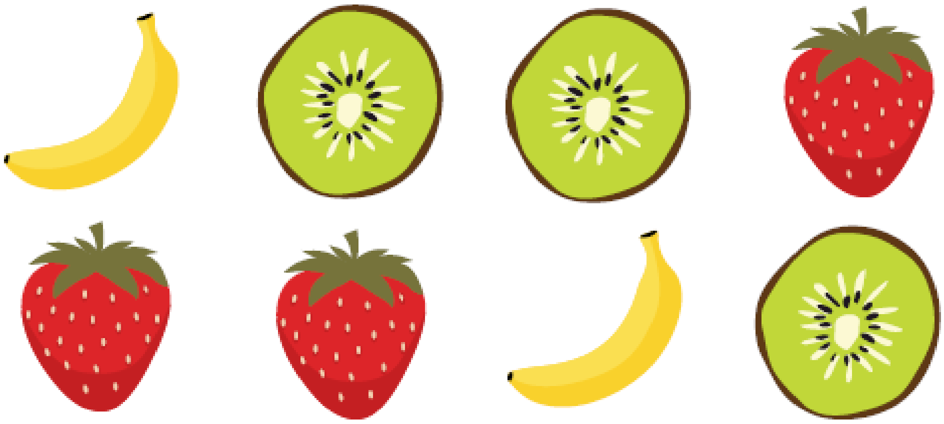
Teste Stroop - Parte A

Instrução: da esquerda para a direita, nomeia o mais rápido possível a cor de cada quadrado.



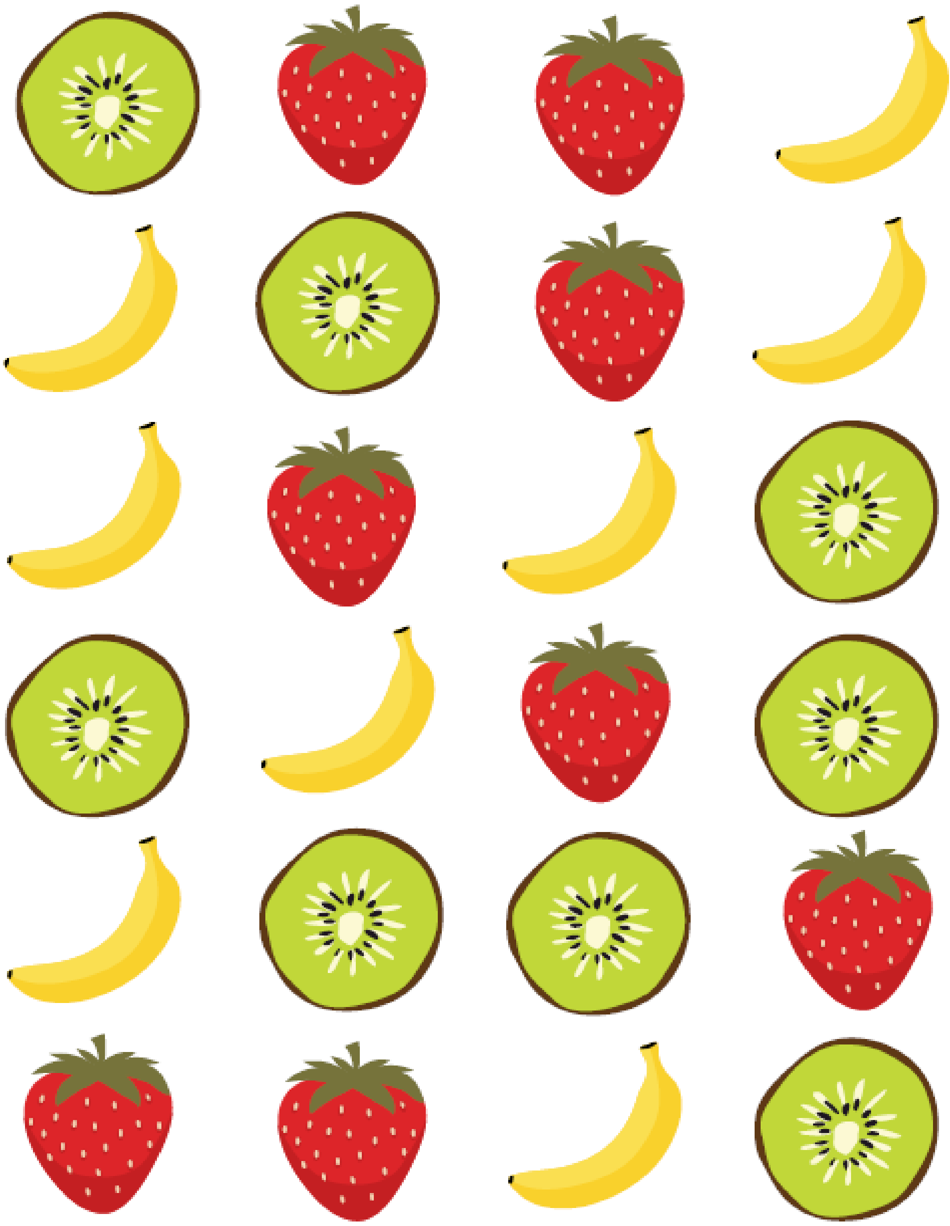
Teste Stroop - Parte B - TREINO

Instrução: da esquerda para a direita, nomeia o mais rápido possível a cor de cada fruta.



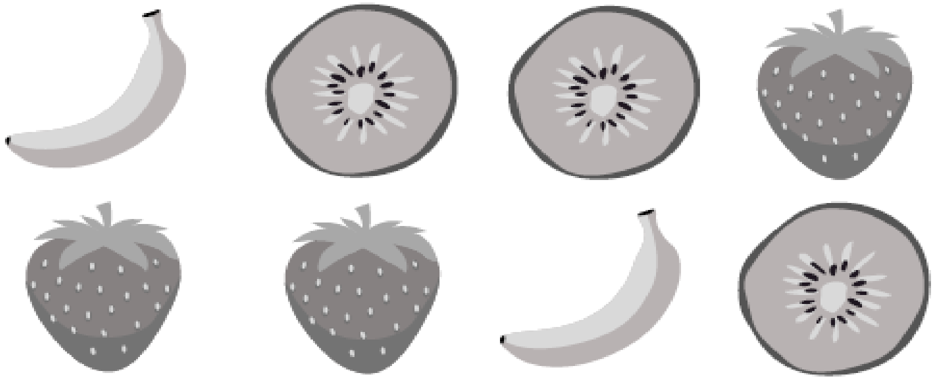
Teste Stroop - Parte B

Instrução: da esquerda para a direita, nomeia o mais rápido possível a cor de cada fruta.



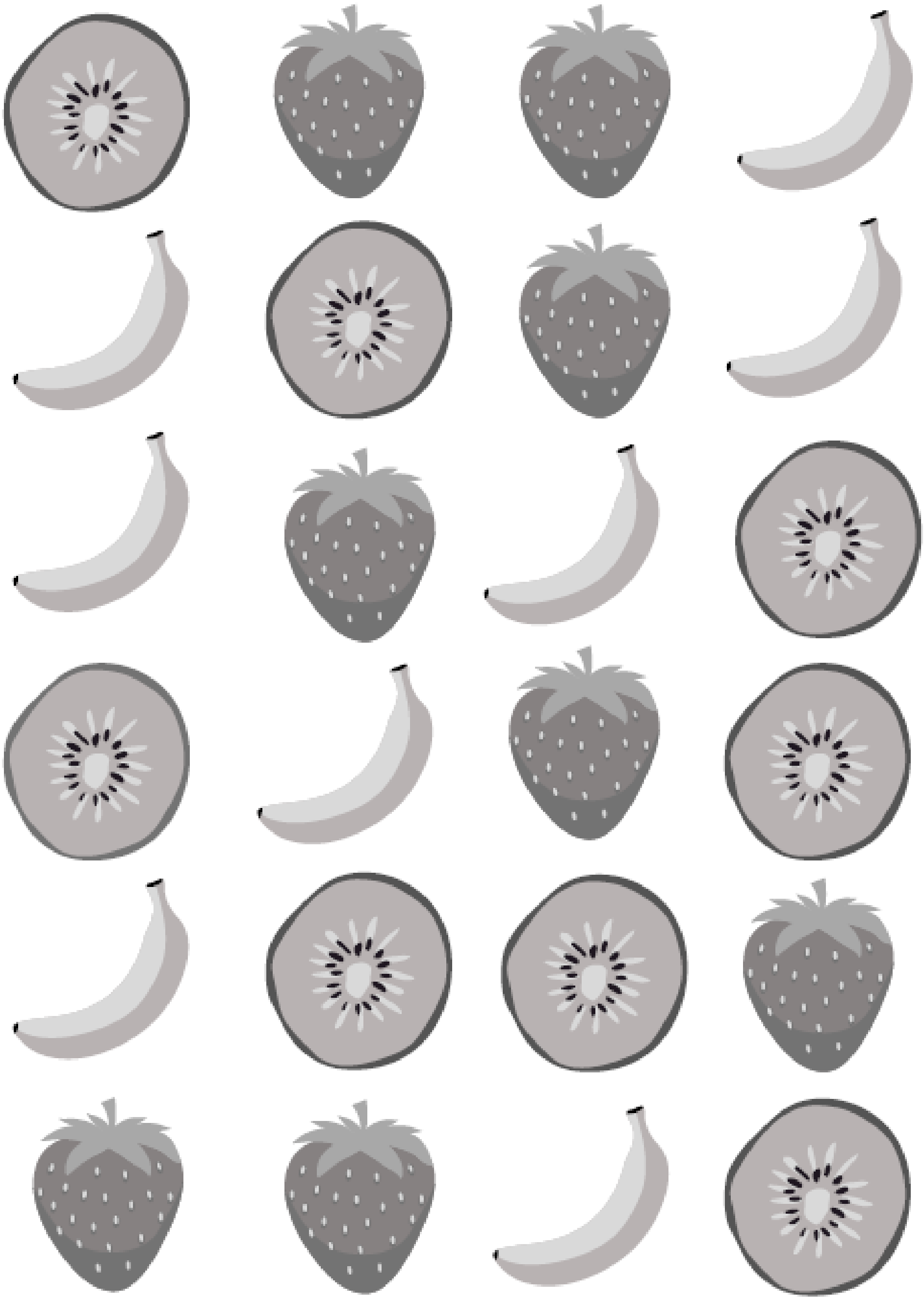
Teste Stroop - Parte C - TREINO

Instrução: da esquerda para a direita, nomeia o mais rápido possível a **cor real** de cada fruta.



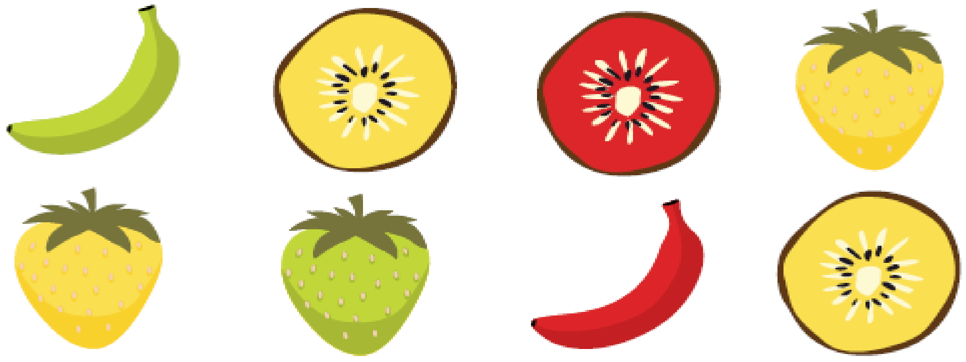
Teste Stroop - Parte C

Instrução: da esquerda para a direita, nomeia o mais rápido possível a **cor real** de cada fruta.



Teste Stroop - Parte D - TREINO

Instrução: da esquerda para a direita, nomeia o mais rápido possível a **cor real** de cada fruta.



Teste Stroop - Parte D

Instrução: da esquerda para a direita, nomeia o mais rápido possível a **cor real** de cada fruta.