Universidade do Minho
Escola de Psicologia

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Between Alarms and Scheduling: The Effect of Cognitive Offloading on Prospective and Retrospective Memory

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Trabalho efetuado sob a orientação do

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junho de 2025

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Joana Silva

(Joana Maria Bairos da Silva)

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I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism, any form of undue use of information, or falsification of results along the process leading to its elaboration.

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Joana Silva

(Joana Maria Bairos da Silva)

Entre Alarmes e Agendamentos: Efeito das Descargas Cognitivas na Memória Prospetiva e Retrospetiva

Resumo

A memória prospetiva (memória de eventos futuros) e a retrospetiva (memória de eventos passados) são fundamentais no dia-a-dia, mas apresentam limitações. Para mitigar estas limitações, pode-se recorrer a estratégias, tais como descargas cognitivas — ações físicas ou ferramentas externas que reduzem o esforço cognitivo de recuperação. Por exemplo, definir um alarme para não esquecer uma tarefa importante. Este estudo investigou o impacto das descargas cognitivas na memória prospetiva e retrospetiva, e se diferentes estratégias de descarga influenciam o desempenho destas memórias. O procedimento envolveu duas fases. Na primeira, os participantes (n = 152) receberam instruções para enviar um e-mail às 19h, 48h depois da primeira fase. A cada participante foi atribuída aleatoriamente uma das seguintes condições: utilização de um lembrete (e.g., alarme); agendamento do e-mail para envio automático; sem recurso a apoios externos. Nesta fase, também assistiram a uma reportagem sobre desinformação. Na segunda fase, os participantes enviavam o e-mail (memória prospetiva) e faziam um relato livre sobre a reportagem (memória retrospetiva). Os resultados mostram que ambas as estratégias de descarga melhoraram significativamente a memória prospetiva. Notavelmente, não houve diferenças significativas no desempenho memória retrospetiva entre condições. Estes dados sugerem que as descargas cognitivas beneficiam sobretudo a precisão da memória prospetiva.

Palavras-chave: descargas cognitivas, memória prospetiva, memória retrospetiva.

Between Alarms and Scheduling: The Effect of Cognitive Offloading on Prospective and Retrospective Memory

Abstract

Prospective (memory of future events) and retrospective memory (memory of past events) are fundamental to proper daily memory functioning, but they face limitations. To mitigate these limitations, individuals may rely on strategies such as cognitive offloading – use of physical actions or external tools to reduce retrieval effort. For example, setting an alarm to avoid forgetting an important task. This study explored the impact of cognitive offloading on prospective and retrospective memory and how different offloading strategies can influence these memories. The procedure involved two phases. In the first, participants (n = 152) were instructed to send an e-mail at 7 pm, 48h after the first phase. Each participant was randomly assigned one of the following conditions: reminder (e.g., alarm), scheduled e-mail for automatic delivery, or no-reminder (internal memory). In this phase, they also watched a news report. In the second phase, the participants sent the e-mail (prospective memory) and had to complete a free recall question about the video (retrospective memory). The results show that both offloading conditions perform significantly better in the prospective task. Notably, there were no significant differences in retrospective memory performance between conditions. These results suggest that cognitive offloading mainly benefits the accuracy of prospective memory.

Keywords: cognitive offloading, prospective memory, retrospective memory.

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Introduction

Remembering what to do and recalling past actions is crucial in proper daily functioning (Talbot et al., 2018). Prospective memory refers to the capacity to create, store, and perform an intention at a specific time in the future in response to an exact cue (Zogg et al., 2012). It describes a person's ability to remember to do something at a specific moment (Einstein et al., 1998; Talbot et al., 2018). It consists of two components: (1) prospective component; (2) retrospective component (Einstein & McDaniel, 1996, as cited in Fellers et al., 2023). Prospective memory involves remembering something you need to do in the future and *when* it needs to be done (e.g., remembering to and when to take your medication). Retrospective memory consists of an event or information about something that has already occurred (e.g., remembering how the medication needs to be taken) (Richmond et al., 2025; Talbot et al., 2018).

Both prospective and retrospective components are theorized to be singly dissociable, as retrospective memory is a necessary but insufficient condition for successful prospective memory (Zogg et al., 2012). Prospective memory, on the other hand, may be shaped by multiple factors, such as the context in which it is planned, recalled and should take place, working memory capacity, social and motivational aspects, and the memory strategies implemented (Ellis & Kvavilashvili, 2000; Richmond et al., 2025).

The literature features a widely conceptual model of prospective memory describing a multi-stage process. The first stage involves the formation of an intention with an associated cue, which may be based on the passage of time or a specific event. The second stage consists of a delay between the formation of the intention and its execution, ranging from minutes to weeks. The third stage consists of accurately detecting and recognizing the cue, leading to a self-initiated retrieval of the associated intention. Several factors can influence detection and recognition in this stage, such as the cue's salience, its relevance to the ongoing task, its association with the intention, and whether it requires detecting the passage of time or the occurrence of an event. Time-based cues are more challenging to detect as they place greater demands on strategic monitoring, whereas event-based cues tend to involve more automatic or spontaneous retrieval processes. The final stages include recalling and executing the intention. Retrospective memory is responsible for recalling the content of the intention, and its accuracy may be affected by the complexity of the information, for example, the volume of the information, its relationship to the intention, and the number of competing intentions present. Execution is often seen as an automatic process, assuming no gross neurological deficits exist (Zogg et al., 2012).

Both prospective and retrospective memories are fundamental in daily tasks. However, their lapses do occur, offering some failures that may impose significant risks to an individual's health and safety. These cognitive processes are vital for sustaining independence, employment, and social interactions (Foster et al., 2009). To minimize these lapses, individuals may implement different cognitive strategies. People who are highly confident of their memory (higher metacognition) are less likely to use such cognitive strategies, whilst people who are less confident of their memory (lower metacognition) rely on them more often (Fellers et al., 2023; Risko & Gilbert, 2016). Some common cognitive strategies include rehearsals or cognitive offloading.

Rehearsals [1] can be triggered by external cues (e.g., smelling coffee and remembering to buy it at the supermarket) or internal cues (e.g., making a mental to-do list and remembering a pending task). This happens in between forming and executing an intention (Fellers et al., 2023). A higher frequency of rehearsals has been associated with improved prospective memory performance (Kvavilashvili & Fisher, 2007).

Cognitive offloading is the strategic use of physical actions or external tools to facilitate information processing and reduce cognitive effort. A typical example is writing down a friend's birthday on your planner as an external aid instead of relying solely on memory. Additionally, cognitive offloading helps us overcome cognitive limitations by manipulating our surroundings or bodily actions (e.g., turning one's head to view an upside-down image rather than mentally rotating it) (Risko et al., 2014; Risko & Gilbert, 2016). Risko and Gilbert (2016) identify several forms of cognitive offloading. One form is external normalization, where individuals manipulate the environment to support cognitive tasks (e.g., using fingers to count for a simple addition). Another is intention offloading, which involves using external reminders to track future tasks (e.g., writing reminders on calendars or post-it notes).

In everyday life, individuals frequently implement cognitive offloading strategies, often without consciously planning them. One example is the widespread habit of taking numerous pictures of various events (e.g., experiences, objects, people) to preserve memories. However, sometimes, implementing cognitive offloading strategies may not work as intended. In some cases, instead of enhancing memory performance, implementing these strategies can be less effective than relying only on internal memory. Soares and Storm (2018) found that people remember observed objects better than those they photographed – when they no longer had access to the photographs. This finding aligns with the

[1] Although we recognize that the term "rehearsals" may not be the most adequate to describe this behavior, we use it to follow the terminology used by Fellers et al. (2023) and to allow a direct comparison between results.

transactive memory theory (Sparrow et al., 2011; Wegner, 1987), which suggests that people rely on external systems to store information. Transactive memory systems allow us to share information with people, technology, and objects, forming what has been described as a prosthetic memory. Since participants assumed they would later access the photographs, they relied on the camera to store the information, engaging less in memory encoding. When access to the photos was denied, their recall performance declines (Soares & Storm, 2018).

Research has shown that cognitive offloading can impact cognitive functioning, sometimes yielding benefits but also carrying potential drawbacks. Prior to deciding to offload information, people tend to perform a cost-benefit analysis of its utility (Gilbert et al., 2023). Among its advantages are enhanced focus on other tasks (Soares & Storm, 2018), a higher probability of recalling the offloaded information, and enhanced prospective memory performance – remembering to execute future tasks (Burnett & Richmond, 2023). Overall, cognitive offloading is recognized as a highly effective and practical strategy (Gilbert et al., 2023). Nonetheless, there are potential drawbacks, particularly a decline in retrieving information when external memory aids (e.g., alarms and *post-it* notes) are no longer available (Lu et al., 2020). A clear example is the photo-taking impairment effect, which suggests that directly observed objects are better remembered than those captured in photographs – particularly when the photos are inaccessible (Henkel, 2014; Soares & Storm, 2018, 2022).

Cognitive offloading has been shown to significantly impact cognitive processes across numerous domains. This study aims to expand upon the work of Fellers et al. (2023). Their research explored the effects of cognitive offloading on a prospective memory task through a two-phase study conducted over a two-day interval. During the first phase, participants were provided with information on "dry eye syndrome" and its treatment and were instructed to e-mail the researcher at a predetermined time (7 pm) two days later. The independent variable (cognitive offloading) had two levels: one in which participants created a reminder and one in which they did not, relying only on their internal memory. Fifteen minutes after the scheduled time (7 pm), all participants received an e-mail with a link requesting information about the treatment of the "dry eye syndrome" – regardless of whether they had completed the prospective task. This allowed researchers to evaluate retrospective memory (memory of past events). The primary aim of this study was to assess the influence of reminders on prospective and retrospective memory. Fellers et al.'s (2023) study has shown that the reminders increased participants' probability of e-mailing the researcher on time and a higher adherence than participants in the internal condition. Unfortunately, they did not find evidence of the effect of setting a reminder on the retrospective memory

task. This result might be explained by the fact that, despite receiving the instructions to set a reminder, they delayed setting it (e.g., an alarm) until after they had finished watching the videos. This can be seen as a critical distinction because the intention to set a reminder might have been sufficient to free up enough cognitive resources for the prospective memory task.

This research is highly relevant to our study, as it serves as the basis for our project. However, we introduce key modifications to Fellers et al.'s (2023) methodology. Unlike Fellers' second experiment, where participants only received the instructions before watching the video, our study requires them to both receive the instructions and set the strategy to see if it increases performance in the retrospective memory task. We also altered the type of information presented in the video, which we adjusted to focus on a more relevant topic to our sample and a pressing contemporary issue: misinformation. Furthermore, we have expanded the cognitive offloading strategy variable to three levels, the new one being an automatic e-mail scheduling mechanism. This new level was introduced so that participants could offload the intention fully since scheduling the e-mail could remove the need to retain the intention in their memory, allowing the possibility to focus solely on the video, unlike the reminder condition that still demands some intention maintenance.

This study pursues two main objectives. First, to deepen the research on the impact of cognitive offloading on prospective and retrospective memory tasks, extending the study by Fellers et al. (2023). Second, to examine the effects of different offloading strategies used on prospective and retrospective memory performance. This leads to our research question, "What is the effect of cognitive offloading on a prospective memory task, considering the strategy implemented?". From this question, we propose four hypotheses: (1) Participants in the reminder and scheduled e-mail condition will have a better performance in the prospective memory task, compared to the participants in the no-reminder condition; (2) Participants who schedule an e-mail (scheduled e-mail condition) will perform better in the retrospective memory task; (3) Participants in the no-reminder condition will engage in more rehearsals than both participants in the offloading conditions (reminder and scheduled e-mail); (4) Participants in both offloading conditions will have higher metacognition than those in the no-reminder condition.

Methods

Participants

The sample size was calculated using G*Power for a One-way ANOVA with three conditions (f = 0.40, α = 0.05, (1-β) = 0.95) (Faul et al., 2007). This analysis indicated a sample size of 102 participants, with 34 participants per condition. However, 152 participants were included to enhance the reliability of the findings and compensate for potential non-adherence (not completing the study's second phase). The participants were recruited through an online participant recruitment system, therefore, they are university students from the University of Minho, all adults with ages ranging between 18 and 53 (M = 22; SD = 6.11).

Design

Cognitive offloading was the independent variable manipulated through a between-subjects design and considering three conditions: reminder vs. scheduled e-mail vs. no-reminder.

The variables that were measured, therefore the dependent variables, were: (1) performance on the prospective memory task (how accurately the participants remember to send the e-mail); (2) performance on the retrospective memory task (participant´s accuracy in recalling the learned information); (3) rehearsals made during the interval between phases; and (4) metamemory, which refers to the confidence participants express when recalling the need to send the e-mail.

Materials

Following the procedure of Fellers et al. (2023), to ensure that the instructions were clear, structured and consistent throughout the experiment, we used a PowerPoint presentation as a visual aid, highlighting the instructions' key points across the slides.

A CBS news report video entitled 'Tracking how dangerous misinformation spreads online' was watched by participants to later evaluate retrospective memory. This news report explained what misinformation is, gave some examples, and provided some strategies on how to stop misinformation from spreading. We selected this topic since it is particularly relevant in today's society. The video duration was 3 minutes and 10 seconds. Given its duration, the video was rich in information and detail. It contained 171 possible information units. Each unit was worth a point, therefore, participants were

awarded a point for every unit that was correctly recalled. The final score had the total number of correct information units and intrusions recalled for further analysis. For instance, the response "Studies about the non-existence of climate change, sunscreen and its cancerous effects" received 5 points, therefore 5 correct information units. Another example is "I remember that the video begins with a journalist in a television studio speaking about fake news. I think it was CBS, and there were white footnotes with black letters supporting the news. Then the broadcast cuts to a man who wasn't in a studio and speaks about the topic, I think he had greyish hair and was wearing a dark long-sleeved shirt. I don't remember what he said, I only remember that he repeated almost the same sentence at the beginning and at the end of his speech. The broadcast then returns to the studio.", which was awarded 11 points for correct information units and 2 intrusions ("wasn't in a studio"; "was wearing a dark long-sleeved shirt).

A Qualtrics (Provo, UT) form was organized into sociodemographic data collection, a metamemory question, and a metamemory scale. The sociodemographic data was assessed by asking participants about their age, sex, nationality and if they had vision or auditory problems. Regarding the metamemory question, the participants were given a question regarding the reminder and no-reminder conditions:

"*How confident/sure are you that you will send the e-mail in 2 days, at 7 pm? We ask you to tell us a number from 0 to 100. "0" corresponds to I don't have any confidence/sureness that I will remember to send the e-mail, and "100" corresponds to I have a huge confidence/sureness that I will remember to send the e-mail.".*

The question that was asked to the participants in the scheduled e-mail condition was slightly different, this one being:

"*How confident/sure are you that the e-mail you programmed will be sent in 2 days, at 7 pm? We ask you to tell us a number from 0 to 100. "0" corresponds to I don't have any confidence/sureness that the e-mail will be sent, and "100" corresponds to I have a huge confidence/sureness that the e-mail will be sent.".*

To assess metamemory, we utilized a Portuguese version of the Multifactorial Memory Questionnaire (Troyer & Rich, 2002; translation by Magalhães de Rooij et al., 2024). This questionnaire measures memory functioning, self-appraisal of memory ability, and self-reported use of memory strategies using three scales. The items are rated on a 5-point Likert scale based on the participant's experience over the previous two weeks. This study only involved the MMQ-Ability scale and the MMQ-

Strategy scale. The MMQ-Ability scale (memory losses) comprises 20 items depicting common memory mistakes. This scale assesses an individual's self-perception of their everyday memory, and it is measured through a score that can range between 0 and 80 (higher scores reflect better self-reported memory ability). The MMQ-Strategy scale (use of memory strategies) comprises 19 items, which portray the use of different memory strategies over the previous two weeks. This scale measures practical memory strategies and tools in everyday life. Scores range between 0 to 76 (higher scores reflect higher use of memory strategies).

A Google Forms was also implemented, where participants had to respond to a free recall question, asking them to remember the maximum information they could about the video. The questionnaire also had some control questions: if they imagined that they were going to be asked to remember information about the video; if they searched for the video on YouTube; if they talked to anybody about the video or the experiment itself; and, if they used any reminder besides the one, they were told to implement. Lastly, the questionnaire had an explanation about what rehearsals are and some questions to which participants had to respond: if they could give some examples of rehearsals that they had experienced in the last hour to estimate how many rehearsals about the study they had experienced during the previous two days; and, finally, to give an example about a rehearsal that may have happened that was related to this experiment.

Procedure

This study had two phases, with a 2-day interval in between. The first phase was conducted in the Human Cognition Laboratory at the University of Minho and lasted 15 minutes. The second phase was conducted online, with a duration of 10 minutes.

In the first phase, participants were instructed to sit in front of a computer, setting themselves approximately 50 cm away from it. First, they had to sign the informed consent form, which contained all the information about the study. After that, they could proceed with the experiment. Initially, all participants received the same instructions: they were told to send an e-mail in 2 days at 7 pm. Following this, they were randomly assigned to one of three conditions: reminder vs. scheduled e-mail vs. no-reminder. In the reminder condition, they were instructed to set a reminder (e.g., alarm, calendar, reminder app) to remind them to send an e-mail in 2 days at 7 pm. In the scheduled e-mail condition, they were guided through setting up an automatic e-mail to be sent at the specified time. In the offloading and scheduled e-mail conditions, both the reminders and the automatic e-mail were set at that moment

before watching the video. Lastly, in the no-reminder condition, they were instructed not to use external aids to remind them about sending the e-mail; therefore, they could only rely on their internal memory to remind them of the task.

The second part of this phase involved a video presentation. After receiving the instructions, which were supported by a PowerPoint presentation, all participants completed the same initial task. They watched an informative video about misinformation or fake news without instructions on remembering the content of the video in the future. Afterwards, they had to respond to a Qualtrics questionnaire with sociodemographic data, a metamemory question, and a metamemory scale, assessed through two scales of the Multifactorial Memory Questionnaire (e.g., the MMQ-Ability scale and the MMQ-Strategy scale).

Two days following the first phase, the participants would send an e-mail at 7 pm and receive an e-mail with a link at 7:15 pm to an online questionnaire (Google Forms). The questionnaire was composed of (1) free recall instruction, in which the participants were requested to remember and describe the details of the video watched in the first phase of the study; (2) control questions; and (3) the use of rehearsal strategies.

Results

Statistical analysis was performed using the jamovi software (version 2.6.26). A significance level of $\alpha = 0.05$ was adopted for all analyses.

Prospective memory – On-time Initiation

To assess whether the condition (reminder vs. scheduled e-mail vs. no-reminder) affected the participant's performance in the prospective task execution (e-mailing the researcher at 7 pm, 2 days after the first phase), a chi-square test of independence was conducted. All the participants who responded within the 15-minute window, before and after 7 pm, were considered "hits", while participants who responded outside that temporal window were considered "misses". The chi-square test suggests a significant association between the condition and on-time initiation, $\chi 2$ (2, N = 152) = 43.40, p <.001, V = .535.

To further examine these differences, pairwise comparisons were made. Participants in the reminder condition revealed a higher proportion of on-time responses (.84) than participants in the no-reminder condition (.37), χ^2 (1, N = 101) = 23.1, p < .001, V = .478, OR = 0.11, 95% CI [0.04, 0.3].

Similarly, participants in the scheduled e-mail (.92) also outperformed those in the no-reminder condition (.37) on the prospective task, χ^2 (1, N = 102) = 33.7, p = < .001, V = .574, OR = 0.05, 95% CI [0.02, 0.2]. On the other hand, participants had a slightly higher level of performance in the scheduled e-mail condition (.92) than in the reminder condition (.84). Still, this difference was not significantly different, χ^2 (1, N = 101) = 1.60, p = .205, V = .126, OR = 2.24, 95% CI [0.63, 8.0]. Participants in the reminder and scheduled e-mail conditions revealed higher on-time response rates compared to the no-reminder condition. These results suggest that participants who relied only on their memory were less likely to execute the prospective task on time than those in both offloading conditions. Notably, four participants in the scheduled e-mail condition might have had scheduling errors or technical issues, and consequently, their e-mail was not sent on time.

Adherence

A chi-square test of independence was also performed to evaluate whether the conditions affected adherence and whether the participants completed the study as a whole. The analysis revealed no significant differences between conditions, χ^2 (2, N = 152) = 0.15, p = .928, V = .031. Therefore, the adherence rate was quite similar between the reminder (.88), scheduled e-mail (.90) and no-reminder (.88) conditions. These results suggest that, even though the condition implemented influenced on-time responses, the condition did not affect whether the participants completed the second task (retrospective task). This may be explained by the reminder that participants received where they were told (again) that they needed to complete the questionnaire (second task) to receive course credits, which likely gave them motivation to respond. This may account for the non-significant differences in adherence.

Retrospective memory

Retrospective memory performance was evaluated through a free report question to which participants had to respond.

We examined whether the participants' retrospective memory performance was affected by the condition in which they were enrolled. Given the violation of normality, a one-way Welch ANOVA was performed to compare the amount of correct information units recalled across all conditions. The results showed no significant differences between conditions, F(2, 84) = 1.12, p = .331, η^2_p = .014. Post hoc tests revealed no significant pairwise differences. These results propose that the type of cognitive

offloading (or its absence) did not significantly impact participants' retrospective memory performance, as shown in Fellers et al.'s (2023) study.

We also analyzed the number of intrusions, such as incorrect information or information not in the video. Once again, due to the violation of normality, a one-way Welch ANOVA was conducted. This analysis showed no significant differences between conditions, $F(2, 85.2) = 0.065$, $p = .937$, $\eta^2_p = .001$. Revealing a similar number of intrusions throughout all conditions: reminder (.77), scheduled e-mail (.69), and no-reminder (.76). Therefore, these results suggest that the condition did not influence the occurrence of memory intrusions in the retrospective memory task.

A one-way Welch ANOVA was performed to compare all three conditions to examine the participants' precision, which is the proportion of correct information units divided by the amount of information recalled. This analysis showed no significant difference between conditions, $F(2, 81.8) = 0.428$, $p = .653$, $\eta^2_p = .009$. The results also reveal similar performance across all conditions: reminder (.94), scheduled e-mail (.91), and no-reminder (.93). This might suggest that the condition did not influence the accuracy of the participants' retrospective recall.

Rehearsals

Before the analysis, ten outliers were removed to prevent extreme values (e.g., 100 rehearsals). Due to violations of normality, a one-way Welch ANOVA was performed to assess whether the number of reported rehearsals differed significantly between conditions. The results reported significant differences between conditions, $F(2, 74.0) = 8.32$, $p < .001$, $\eta^2_p = .137$. Games-Howell post hoc analysis suggested that the no-reminder condition ($M = 5.77$, $SD = 5.39$) had a significantly higher number of rehearsals than the reminder ($M = 3.50$, $SD = 1.78$) and scheduled e-mail (M = 2.57, SD = 1.64) conditions. These results suggest that participants in the no-reminder condition – relying solely on their memory – rehearsed more than participants in both offloading conditions.

Metamemory

To assess participants' confidence in sending the e-mail – or for the e-mail to be sent – we performed a one-way Welch ANOVA due to violations of the assumption of normality. This analysis revealed a significant difference between conditions, $F(2, 92.4) = 25.4$, $p < .001$, $\eta^2_p = .341$. Post hoc comparisons showed that participants in both the reminder ($M = 88.9$, $SD = 11.4$) and scheduled e-mail

(*M* = 92.7, *SD* = 10.3) condition rated their confidence in memory significantly higher than those in the no-reminder condition (*M* = 64.5, *SD* = 26.2). No significant differences were observed between the reminder and scheduled e-mail conditions (p = .187). These findings suggest that external aids (e.g., alarm, reminder app, calendar) might enhance confidence in memory performance.

Table 1

Results by Condition

Measure	Reminder	Scheduled E-mail	No-reminder	*p-value*, effect size
On-time initiation (Hits)	42 of 50	47 of 51	19 of 51	$p < .001$, $\chi^2 = 43.4$
Adherence	44 of 50	46 of 51	45 of 51	$p = .928$, $\chi^2 = 0.149$
Confidence (On-time initiation)	88.9 (11.4)	92.7 (10.3)	64.5 (26.2)	$p < .001$, F (2, 92.4) = 25.4
Rehearsals	3.50 (1.78)	2.57 (1.64)	5.77 (5.39)	$p < .001$, F (2, 74.0) = 8.32
Retrospective Memory	10.66 (8.84)	8.44 (5.77)	9.91 (8.70)	$p = .331$, F (2, 84.0) = 1.12

Correlations Between Cognitive Measures

Spearman correlation analyses were conducted to explore the possible relationships between self-reported metamemory and both scales of the MMQ (e.g., ability and strategy scales) since the self-reported metamemory variable did not follow a normal distribution across all conditions. Participants who reported higher confidence in remembering the prospective task tended to score higher on the MMQ – Ability scale – r_s = .273, $p < .001$ – but, on the other hand, the reported confidence variable did not seem to relate to the use of memory strategies (MMQ – Strategy scale) – r_s =.056, p = .494. According to the data, both MMQ scales were significantly and negatively correlated (r_s = -.467, $p < .001$). This result might suggest that participants who reported a higher "everyday memory ability" tended not to rely as much on memory strategies.

In terms of prospective task performance, Spearman correlations revealed that there was a significantly positive correlation between on-time initiation and self-reported metamemory (confidence in remembering to send the e-mail) (r_s = 0.436, $p < .001$). This result suggests that individuals who rated higher confidence in their memory to send the e-mail tended to perform better on the prospective memory task (send the e-mail on time). On the other hand, adherence to the second part of this study was not significantly correlated to any of the measured variables, for example, on-time initiation (r_s = 0.142, p = .082).

Regarding retrospective performance, the number of correct information units recalled from the video previously watched was not correlated to self-reported metamemory or both MMQ scales scores. Nevertheless, participants with higher use of memory strategies tended to produce more intrusions (r_s = .238, p = .005), and there was a tendency for participants with higher memory ability to produce fewer intrusions (r_s = -.178, p = .039).

Discussion

This study aimed to explore the impact of cognitive offloading on prospective and retrospective memory whilst analyzing how different strategies of cognitive offloading can influence these memories. To explore these aspects, we conducted a two-phase procedure. In the first phase, participants were instructed to send an e-mail at a designated time (7 pm), 48 hours after the initial meeting with the researcher. Each participant was randomly assigned to one of three conditions to help with timely e-mail delivery: reminder (e.g., alarm, calendar); scheduled e-mail; and no-reminder (relying solely on their memory, therefore no cognitive offloading). During this first phase, participants watched a CBS news report about how to identify and prevent the spread of misinformation. In the second phase, 48 hours later, participants sent the e-mail (prospective memory task) at the specified time. At 7:15 pm (15 minutes after they had to send the e-mail), all participants received a link to a questionnaire, where they had to respond to a free recall question about the video content (retrospective memory task) and a few control questions about what they may have done in-between sessions (e.g., use of rehearsal strategies). Following the paradigm of Fellers et al. (2023), we can examine, as they did, the relationship between cognitive offloading, rehearsals, and metamemory and their influence on prospective and retrospective memory.

As expected, participants who offloaded had a higher chance of e-mailing the researcher at the designated time - producing results similar to those of Fellers et al. (2023) in prospective memory performance. Therefore, participants in both offloading conditions (reminder and scheduled e-mail) showed higher performance in the prospective memory task (e-mailing the researcher on time) than participants who relied solely on their memory (no-reminder). These results show the efficacy of completing a prospective task when setting a reminder in a naturalistic context – thus confirming our first hypothesis –, which suggests that the use of external reminders reduces cognitive load and enhances the likelihood of pursuing a future intention (Burnett & Richmond, 2023; Soares & Storm, 2018).

There were no significant differences between conditions regarding adherence (completing the second phase of the study, the retrospective task) - most participants completed the retrospective task throughout all conditions. We had contrasting results in adherence when compared to Fellers et al. (2023). These results can be explained by the researcher's second reminder to complete the second task to receive course credits (participants only received course credits if they completed the retrospective task)– which may have attenuated differences between groups. This methodological aspect (second reminder) differs from Fellers et al. (2023), who didn't send a second reminder for the retrospective task. For future studies, it would be important to avoid sending a second reminder to determine whether this influences adherence and if we can observe differences between the three conditions. According to the social perspective that Fellers et al. (2023) follow (e.g., cognitive dissonance: Harmon-Jones & Harmon-Jones, 2007; saying-is-believing theory: Higgins & Rholes, 1978), the reminder condition would have a higher adherence in completing the retrospective task, since setting a reminder might increase the perceived importance and could influence their subsequent behavior (completing the retrospective task). Following this perspective, we believe that the reminder condition would have a higher adherence to the second task than the scheduled e-mail and no-reminder conditions since there could be a drive to remain consistent - successful in both tasks - complying with them to complete the retrospective task.

Contrary to our second hypothesis, neither of the cognitive offloading conditions led to better retrospective memory task performance when compared to the no-reminder condition. This result is consistent with previous findings, such as those of Fellers et al. (2023) and Kvavilashvili (1987), where retrospective memory performance is independent of prospective memory performance. Since the participants in the scheduled e-mail would offload their intention fully - not needing to actively retain and maintain it - we believe that it would enable them to focus entirely on the information transmitted in the video, improving their retrospective memory performance. Contrary to expectations, no differences were observed between the reminder and scheduled e-mail conditions. One possible explanation for these statistically nonsignificant results is the familiarity with the information in the video (how to identify and prevent the spread of misinformation) since misinformation is a widely approached topic (Allcott & Gentzkow, 2017; Lazer et al., 2018). Rather than recalling the information in the video, participants may have recalled prior knowledge about the issue. Our results are similar to those of Fellers et al. (2023) since no statistically significant differences were found in both studies. Whilst Fellers et al. (2023) reported similar means across both conditions (Offloading: M = .43; Internal: M = .43), our study also didn't find any significant differences in retrospective memory performance in-between conditions (Reminder = 10.66; Scheduled e-mail = 8.44; No reminder = 9.91). To research these results further, future research

may explore if resorting to more unfamiliar information and detail-specific stimuli can lead to significant differences in recall accuracy between cognitive offloading strategies.

Confirming our third hypothesis, individuals who relied solely on their memory engaged in more rehearsals - nonintentional reminding of a future intention - than external tools. This result supports the idea that when we cannot rely on external tools, we tend to compensate for possible lapses of memory by interacting with and monitoring the intention, through cognitive strategies – in this case, through rehearsals (Fellers et al., 2023; Zogg et al., 2012).

Lastly, we confirmed our fourth hypothesis, therefore, both offloading conditions had higher levels of confidence in sending the e-mail on time or that the e-mail would be sent (scheduled e-mail condition) when compared to the no-reminder condition – which supports the idea that external aids might increase confidence in prospective memory performance (Gilbert et al., 2023). The correlation between metamemory and prospective memory performance revealed a relationship between both, which might indicate that individuals with higher levels of confidence in remembering to send the e-mail tended to perform better on the prospective memory task.

The results of this study might offer important insights that can be translated into practical implications. These practical implications can affect a wide range of areas, from medicine to educational contexts, where management of prospective (future events) and retrospective tasks (past events) are a daily occurrence (e.g., medical treatments). Even though most findings show a positive relationship between cognitive offloading and prospective memory, there might be some strategies in cognitive offloading - like a reminder with a descriptive label - that may improve retrospective memory by presenting context-specific cues at retrieval (Morrison & Richmond, 2020; Richmond et al., 2023). Therefore, cognitive offloading might benefit both prospective and retrospective memory - although more studies are needed to understand the impact of offloading on the retrospective component - avoiding possible memory lapses.

Future research can build on these findings by addressing the above-mentioned limitations. A promising approach would be to use a retrospective memory task with a less familiar topic or a more emotionally engaging material, which could show some differences in performance with the use of strategies of cognitive offloading. Another interesting approach would be to expand participant samples beyond university students, which could give us a more heterogeneous sample and allow us to observe how these offloading strategies affect different populations.

This research has helped to understand the role of cognitive offloading strategies, highlighting its effects on prospective memory – objectively (sending the e-mail on time) or subjectively (enhancing confidence in their memory). Nonetheless, this study also shows that using these strategies doesn't imply improvements in all domains (e.g., retrospective memory).

References

Allcott, H., & Gentzkow, M. (2017). Social media and fake news in the 2016 election. *Journal of economic perspectives*, *31*(2), 211-236. https://doi.org/10.1257/jep.31.2.211

Burnett, L. K., & Richmond, L. L. (2023). Just write it down: Similarity in the benefit from cognitive offloading in young and older adults. *Memory & Cognition*, *51*(7), 1580-1592. https://doi.org/10.3758/s13421-023-01413-7

Einstein, G. O., McDaniel, M. A., Smith, R. E., & Shaw, P. (1998). Habitual prospective memory and aging: Remembering intentions and forgetting actions. *Psychological Science*, *9*(4), 284–288. https://doi.org/10.1111/1467-9280.00056

Ellis, J., & Kvavilashvili, L. (2000). Prospective memory in 2000: Past, present, and future directions. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, *14*(7), S1-S9. https://doi.org/10.1002/acp.767

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Fellers, C., Miyatsu, T., & Storm, B. C. (2023). Remembering what to do when the time comes: The effects of offloading in a complex prospective memory task. *Journal of Experimental Psychology: Applied*, *29*(3), 631–644. https://doi.org/10.1037/xap0000449

Foster, E. R., McDaniel, M. A., Repovs, G., & Hershey, T. (2009). Prospective memory in Parkinson disease across laboratory and self-reported everyday performance. *Neuropsychology*, *23*(3), 347–358. https://doi.org/10.1037/a0014692

Gilbert, S. J., Boldt, A., Sachdeva, C., Scarampi, C., & Tsai, P. C. (2023). Outsourcing memory to external tools: A review of 'intention offloading'. *Psychonomic Bulletin & Review*, *30*(1), 60-76. https://doi.org/10.3758/s13423-022-02139-4

Harmon-Jones, E., &Harmon-Jones,C.(2007). Cognitive dissonance theory after 50 years of development. *Zeitschrift für Sozialpsychologie*, *38*(1), 7–16. https://doi.org/10.1024/0044-3514.38.1.7

Henkel, L. A. (2014). Point-and-shoot memories: The influence of taking photos on memory for a museum tour. *Psychological science*, *25*(2), 396-402. https://doi.org/10.1177/0956797613504438

Higgins, E. T., & Rholes, W. S. (1978). “Saying is believing”: Effects of message modification on memory and liking for the person described. *Journal of Experimental Social Psychology*, *14*(4), 363–378. https://doi.org/10.1016/0022-1031(78)90032-X

Kvavilashvili, L. (1987). Remembering intention as a distinct form of memory. *British Journal of Psychology*, *78*(4), 507–518. https://doi.org/10.1111/j.2044-8295.1987.tb02265.x

Kvavilashvili, L., & Fisher, L. (2007). Is time-based prospective remembering mediated by self-initiated rehearsals? Role of incidental cues, ongoing activity, age, and motivation. *Journal of experimental psychology. General*, *136*(1), 112–132. https://doi.org/10.1037/0096-3445.136.1.112

Lazer, D. M., Baum, M. A., Benkler, Y., Berinsky, A. J., Greenhill, K. M., Menczer, F., ... & Zittrain, J. L. (2018). The science of fake news. *Science*, *359*(6380), 1094-1096. https://doi.org/10.1126/science.aao2998

Morrison, A. B., & Richmond, L. L. (2020). Offloading items from memory: Individual differences in cognitive offloading in a short-term memory task. *Cognitive Research: Principles and Implications*, *5*, 1-13. https://doi.org/10.1186/s41235-019-0201-4

Richmond, L. L., Kearley, J., Schwartz, S. T., & Hargis, M. B. (2023). Take a load off: examining partial and complete cognitive offloading of medication information. *Cognitive research: principles and implications*, *8*(1), 12. https://doi.org/10.1186/s41235-023-00468-z

Richmond, L. L., Burnett, L. K., Kearley, J., Gilbert, S. J., Morrison, A. B., & Ball, B. H. (2025). Individual differences in prospective and retrospective memory offloading. *Journal of Memory and Language*, *142*, 104617. https://doi.org/10.1016/j.jml.2025.104617

Risko, E. F., Medimorec, S., Chisholm, J., & Kingstone, A. (2014). Rotating with rotated text: A natural behavior approach to investigating cognitive offloading. *Cognitive Science*, *38*(3), 537-564. https://doi.org/10.1111/cogs.12087

Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in cognitive sciences*, *20*(9), 676-688. https://doi.org/10.1016/j.tics.2016.07.002

Soares, J. S., & Storm, B. C. (2018). Forget in a flash: A further investigation of the photo-taking-impairment effect. *Journal of Applied Research in Memory and Cognition*, *7*(1), 154-160. https://doi.org/10.1016/j.jarmac.2017.10.004

Soares, J. S., & Storm, B. C. (2022). Does taking multiple photos lead to a photo-taking -impairment effect? *Psychonomic Bulletin & Review*, *29*(6), 2211–2218. https://doi.org/10.3758/s13423-022-02149-2

Sparrow, B., Liu, J., & Wegner, D. M. (2011). Google effects on memory: Cognitive consequences of having information at our fingertips. *Science*, *333*(6043), 776-778. https://doi.org/10.1126/science.1207745

Talbot, K.-D. S., Müller, U., & Kerns, K. A. (2018). Prospective memory in children with attention deficit hyperactivity disorder: A review. *The Clinical Neuropsychologist*, *32*(5), 783–815. https://doi.org/10.1080/13854046.2017.1393563

The jamovi project (2025). jamovi (Version 2.6) [Computer Software]. Retrieved from https://www.jamovi.org

Troyer, A. K., & Rich, J. B. (2002). Psychometric properties of a new metamemory questionnaire for older adults. *The Journals of Gerontology: Series B, Psychological Sciences*, *57*(1), P19-P27. Translated to Portuguese by Filipa Magalhães de Rooij, Nuno Gaspar, and Pedro Albuquerque, Universidade do Porto and Universidade do Minho.

Wegner, D.M. (1987). *Transactive Memory: A Contemporary Analysis of the Group Mind*. In: Mullen, B., Goethals, G.R. (eds) Theories of Group Behavior. Springer Series in Social Psychology. Springer, New York, NY. https://doi.org/10.1007/978-1-4612-4634-3_9

Zogg, J. B., Woods, S. P., Sauceda, J. A., Wiebe, J. S., & Simoni, J. M. (2012). The role of prospective memory in medication adherence: a review of an emerging literature. *Journal of behavioral medicine*, *35*(1), 47–62. https://doi.org/10.1007/s10865-011-9341-9

Appendix

PARECER

A Comissão de Ética para a Investigação em Ciências Sociais e Humanas (CEICSH) analisou o processo relativo ao projeto de investigação acima identificado, intitulado *Efeito da Descarga Cognitiva na Memória Prospetiva: O Papel da Relevância no Sucesso da Tarefa*.

Os documentos apresentados revelam que o projeto obedece aos requisitos exigidos para as boas práticas na investigação com humanos, em conformidade com as normas nacionais e internacionais que regulam a investigação em Ciências Sociais e Humanas.

Face ao exposto, a Comissão de Ética para a Investigação em Ciências Sociais e Humanas (CEICSH) nada tem a opor à realização do projeto nos termos apresentados no Formulário de Identificação e Caracterização do Projeto, que se anexa, emitindo o seu parecer favorável, que foi aprovado por unanimidade pelos seus membros.

Braga, 19 de julho de 2024.

A Vice-Presidente da CEICSH

Assinado por: **Cristina Maria Moreira Flores**
Num. de Identificação: 12028714
Data: 2024.07.19 22:16:30+01'00'

(Cristina Maria Moreira Flores)