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Research Paper

Road to Successful Prospective Memory Execution: Comparing Event Based and Time Based Intentions

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ABSTRACT

Time Based (TB) and Event Based (EB) Prospective Memory (PM) tasks differ at very basic level. In EB PM tasks, the target cue is explicitly present in the environment, whereas in TB PM tasks, the target cue is temporal and relies more on self-initiated monitoring. In this study, researchers aimed to empirically find the difference in the performance over a TB and EB PM tasks when other factors like Ongoing Task (OT), PM tasks, target cues and temporal intervals are same. Researchers additionally manipulated the relative importance of PM task by rewarding either PM task performance, OT performance or giving or reward for any task. A total of 128 participants were divided into two groups. All the participants performed four test blocks (two of TB PM task and two of EB PM task) having same OT and PM tasks. The two groups differed in the reward conditions. Group 1 (n=77) was either rewarded for successful OT performance or given no reward. Group 2 (n=51) was either rewarded for successful PM performance or given no reward. Results showed that the performance over EB PM task was consistently better than that on TB PM task irrespective of the reward condition.

Keywords: *Prospective Memory, Event Based Prospective Memory, Time Based Prospective Memory, Ongoing Task, Prospective Memory Task*

Prospective memory (PM) is the ability to remember to carry out intentions in the future, either at a specific time or in response to a particular event (Einstein & McDaniel, 1990). Unlike retrospective memory, which concerns recalling past information, prospective memory is inherently future-oriented and plays a critical role in daily functioning, ranging from remembering to take medications to attending scheduled appointments (Kvavilashvili & Ellis, 1996). Paradigm of a prospective memory task includes encoding of the intention of performing a task in future and then recalling that intention at the critical moment in future (on occurrence of a particular even or at a particular time in future). The interval between encoding and retrieval is never free. The person is involved in single or a number of activities during the encoding and retrieval. This is called Ongoing Task.

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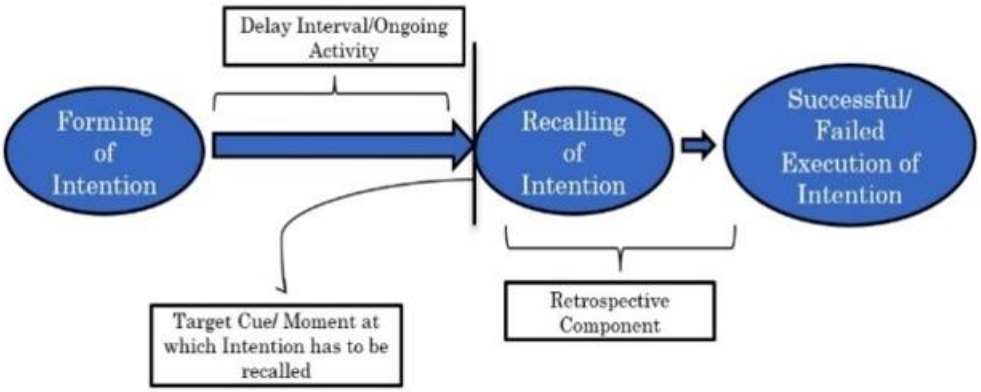
Figure1 Showing General Paradigm of Prospective Memory Task in Daily Life



Broadly, prospective memory tasks are classified into two categories: time-based (TB) tasks, which require individuals to perform an action at a specific time or after a certain duration, and event-based (EB) tasks, which involve executing an intention when a particular external cue is encountered (Ellis & Kvavilashvili, 2000). This external cue is often termed as target cue.

Understanding the differences between time-based and event-based PM is important because they rely on distinct cognitive processes and may be differentially affected by factors such as attention, executive control, and aging. Comparing performance across these two task types provides insights into the mechanisms that underlie successful future-oriented behavior and has implications for both theoretical models and applied settings.

Research has consistently demonstrated that event-based prospective memory tasks are generally easier to perform than time-based tasks (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). This difference is largely attributed to the availability of external cues in event-based tasks, which serve as reminders to execute the intended action (McDaniel & Einstein, 2000). In contrast, time-based tasks place a heavier demand on self-initiated monitoring, such as clock checking, because the external environment does not naturally signal when the intended action should be performed (Harris & Wilkins, 1982).

Cognitive theories suggest that event-based PM tasks often involve more automatic retrieval processes, as the appearance of a salient cue can spontaneously trigger the retrieval of the intention (McDaniel & Einstein, 2007). Time-based tasks, however, are believed to rely more on strategic monitoring processes, requiring attentional resources and executive functioning to maintain the intention and track elapsed time (Smith, 2003). This makes time-based tasks more cognitively demanding and more vulnerable to failures, especially under conditions of divided attention.

Empirical findings further support this distinction. For example, studies show that performance on time-based tasks declines with increasing task complexity and reduced opportunities for time monitoring (Block & Zakay, 2006; Mäntylä, 1996). On the other hand, event-based tasks are relatively less affected by attentional load when the event cue is distinctive and salient, although performance may decline when cues are non-salient or embedded in complex ongoing activities (Scullin, McDaniel, & Einstein, 2010).

Age-related research has also highlighted differential patterns. Older adults often perform as well as younger adults on event-based PM tasks with salient cues but show deficits on time-based tasks (Henry, MacLeod, Phillips, & Crawford, 2004). This supports the notion that time-based tasks impose greater demands on executive resources, which are more susceptible to age-related decline.

In applied contexts, these distinctions have practical significance. For instance, in healthcare, remembering to take medication at specific times (a time-based task) is often more challenging than remembering to take medication when eating meals (an event-based task). Understanding these differences can inform the design of interventions, reminders, and cognitive training programs aimed at improving everyday prospective remembering.

In the present paper, researchers will try to find the answer of following questions:

1. Is there is any difference between performance of a participant over different types of PM task, i.e. Time Based PM task and Event Based PM task?
2. Is this difference effected by manipulating the relative importance of PM task?

METHOD

Sample

The participants for this study were adults of age ranging from 18-29. The details of the sample are given in the table below:

Table 1 Sample Details

Block	Valid Sample	Discarded Sample	Number (Valid) of Males and Females	Minimum Age	Maximum Age	Average Age
Group 1 (OT Reward or No Reward)	77	19	Females- 34 Males- 43	18	27	21.73
Group 2 (PM Reward or No Reward)	51	1	Females- 30 Males- 21	18	29	23.02
Overall Total	128	20	Females- 64 Males- 64	18	29	21.97

The data of 20 candidates was discarded during analysis because the candidates had shown retrospective error. Additionally, one candidate in Group 1 couldn't complete 3rd block (i.e. OT Reward block of EB PM Task). Hence, whenever there is an analysis of EB OTR block, n=76 was considered.

Current Study Paradigm:

The paradigm of the current study has been frequently used by many studies in past for measuring prospective memory. Participants had to do one ongoing task (OT) and the PM tasks was embedded into it. They were to execute the PM tasks at the critical moment that was already explained to them during the instructions (Albiński, Kliegel, and Gurynowicz, 2016; Meier and Zimmermann, 2015; Scullin et al, 2010; Brandimonte et al, 2015; Ellis, Kvavilashvili, Milne, in 1999; Zuber et al, 2024; Basu and Mukherjee, 2022).

Materials:

Ongoing Task:

The OT for this study was solving reasoning type questions. However, logic of each question was mentioned in the question statement itself. The respondents needed to apply that logic and solve the questions. This ensured that the participants who are weak in solving such questions do not get discouraged. The OT questions were validated by administering them on 5 demo candidates.

Each participant completed four blocks of OT and PM task out of which first two blocks belonged to TB PM task and last two blocks belonged to EB PM tasks. The timing of the blocks was of 20 minutes. In a block of 20 minutes, a candidate was presented with 50 OT questions. Timing for each question was 24 seconds. This timing was ascertained based on the performances of demo candidates. However, the candidates were not told about this timing. Instead, they were told that each question will change automatically after some time and they had to mark their responses during that duration only.

Prospective Memory Task:

Each block had 4 instances of prospective memory task. The task for TB blocks was to record the question numbers a candidate was doing exactly at the end of 5^{th}, 9^{th}, 15^{th}, and 19^{th} minute, i.e. 4:59, 8:59, 14:59, 18:59. The questions appearing at these moments were equally distributed around this time. This means that the question started 12 seconds before this time and ended 12 seconds after this time. Any participant responding in this window will be considered as correctly executing PM task. The questions were presented in a jumbled order to avoid guessing by the participants. To see the exact time elapsed since the start of test, the candidates can press "Ctrl" key of the keyboard. On pressing Ctrl, a clock will appear for 3 seconds.

For EB blocks, the PM task was to record the number of those questions which contained word "University". The questions in the EB blocks were arranged in such a way that the questions containing PM target cue appeared exactly at those times when they appeared in TB blocks, i.e. 5^{th}, 9^{th}, 15^{th}, and 19^{th} minutes.

For performing the PM task, they needed to press "Alt" key on the keyboard. On pressing Alt key, a new window appeared where they can record the question number.

Manipulating relative Importance of Prospective Memory Task:

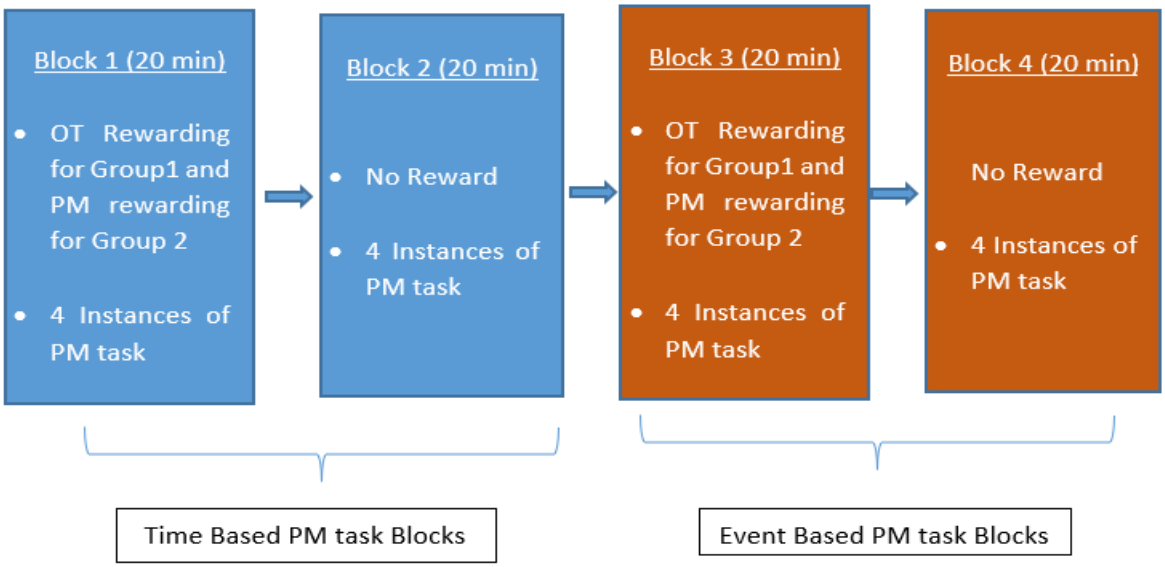
To manipulate the relative importance of Prospective Memory task either PM performance was rewarded or OT performance was rewarded or either no reward was given for any task. The reward was that top three performers will be given Amazon Voucher.

Procedure

The study had two groups of participants. Both the groups completed four blocks of OT+PM task. First two block corresponded to TB PM task whereas last two blocks corresponded to EB PM task. Out of the first two blocks of TB PM task, one was made rewarding and other was non rewarding. Similarly, out of the last 2 blocks of EB PM task, one was made rewarding and other was made non-rewarding. The two groups differed in the condition of reward. For first group reward (wherever applicable) was given for successful performance of OT (also referred to as OTR-NR group). Whereas, for second group, reward (wherever

applicable) was given for successful performance of PM task (also referred to as PMR-NR group).

Figure 2 Showing Design of the Current Study



The details of PM task, OT and reward condition were clearly and explicitly mentioned in the instructions before each block. In blocks where, PM task was rewarding, additional instruction was given that "in case of tie, the candidates performing better on OT will be given preference" This was done to ensure that candidates don't stop doing OT and wait for PM task moments only.

After the instructions the participants were given two examples to acquaint them with the screen, presentation of questions, method of responding, method of seeing clock, pattern of clock, location of clock and method of performing PM task
After the end of first two blocks (TB blocks), participants were asked following questions:

a. The time at which questions numbers had to be recorded
b. Which button to be pressed for seeing the clock?
c. Which button to be pressed for recording the question number?

After the end of last two blocks (EB blocks), participants were asked following questions:

a. On seeing which word, the question number was to be recorded?
b. Which button was to be pressed for recording the question number?

This was done to ensure that the failure to perform PM task was not due to retrospective or coding error.

RESULTS

Two 2X2 repeated measure ANOVA were performed to see the interaction effect of reward and type of PM task, i.e. TB or EB, in Group 1 and 2. Then, paired sample t-tests were performed to see the effect of type of PM task on PM performance in corresponding reward condition of TB and EB PM tasks.

There were 4 instances of PM task in each of the four blocks, hence, maximum and minimum possible score for every individual in each block is 4 and 0 respectively.

Analysis for Group 1 (OTR-NR Group):

Table 2 Mean (SD) of PM Performance Under Different Conditions of Group 1 (OTR-NR Group) (n=76):

	OT Reward	No Reward
TB PM Task	1.30 (1.541)	1.92 (1.364)
EB PM Task	2.07 (1.436)	2.37 (1.345)

Table 3: Interaction Effect of Reward and Type of PM task over PM Performance in Group 1 (OTR-NR Group) (n=76):

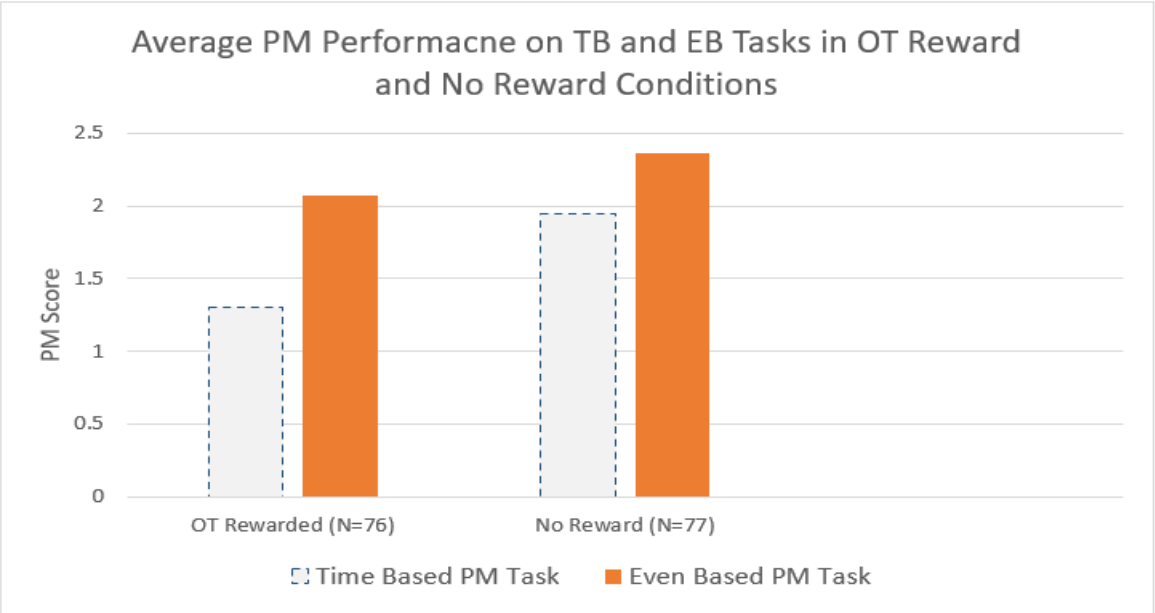
F (Interaction)	df (Total)	df (Between Subjects)	df (Within Subjects)	Sig
1.613	303	75	228	0.208

The above table shows that the interaction effect of Reward and Type of PM tasks over PM performance fails to reach any significance level.

Table 4 Comparing PM Performance on EB and TB PM task for the corresponding Reward Conditions in Group 1 (OTR-NR Group):

Reward Condition	Type of PM task	Mean (SD)	Paired Sample t value (Sig Level)	df
OT Rewarded (n=76)	Time Based	1.30 (1.541)	-3.373** (0.001)	75
	Event Based	2.07 (1.436)		
No Rewarded (n=77)	Time Based	1.95 (1.376)	-2.111* (0.038)	76
	Event Based	2.36 (1.337)		

Figure 3 Showing Average PM Score of All Participants on TB and EB PM tasks in Group 1 (OT Rewarded – No Reward Group)



The above table and graph shows that the average performance over EB PM task was consistently higher than that on TB PM task over both reward conditions i.e. OT Reward and No Reward Conditions. When OT was rewarded, the difference was significant (t= -3.373) at p=0.001. When No reward was given, the difference was significant (t=-2.111) at p=0.038.

Analysis for Group 2 (PMR-NR Group):

Table 5 Mean (SD) of PM Performance Under Different Conditions of Group 2 (PMR-NR Group) (n=51):

	PM Reward	**No Reward**
TB PM Task	3.02 (1.104)	2.51 (1.332)
EB PM Task	3.39 (0.896)	3.02 (1.029)

Table 6: Interaction Effect of Reward and Type of PM task over PM Performance in Group 2 (PMR-NR Group) (n=51):

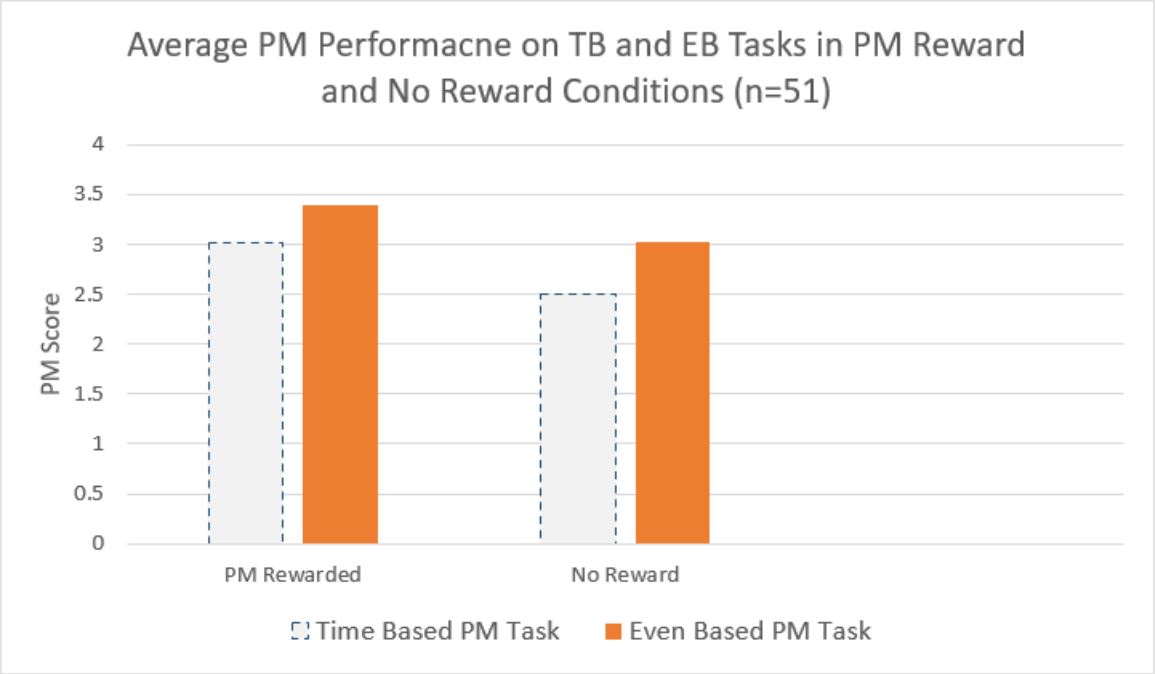
F (Interaction)	**df (Total)**	**df (Between Subjects)**	**df (Within Subjects)**	**Sig**
0.238	204	50	154	0.628

The above table shows that the interaction effect of Reward and Type of PM tasks over PM performance fails to reach any significance level.

Table 7 Comparing PM Performance on EB and TB PM task for the corresponding Reward Conditions in Group 2 (PMR-NR Group) (n=51):

Reward Condition	**Type of PM task**	**Mean (SD)**	**Paired Sample t value (Sig Level)**	**df**
PM Rewarded	Time Based	3.02 (1.104)	-2.188* (0.033)	50
	Event Based	3.39 (0.896)		
No Rewarded	Time Based	2.51 (1.332)	-2.515* (0.015)	50
	Event Based	3.02 (1.029)		

Figure 4 Showing Average PM Score of All Participants on TB and EB PM tasks in Group 2 (PM Rewarded – No Reward Group)



The above table and graph shows that the average performance over EB PM task was consistently higher than that on TB PM task over both reward conditions i.e. PM Reward and No Reward Conditions. When PM task was rewarded, the difference was significant (t= -2.188) at p=0.033. When No reward was given, the difference was significant (t=-2.515) at p=0.015.

DISCUSSION

The present study aimed to compare the performance over TB and EB PM tasks. The study also wanted to explore that if this difference is effected by manipulating the relative importance of the PM task.

Consistent with previous researches, the results demonstrated that participants performed significantly better on EB tasks than TB tasks irrespective of whether OT was important, or PM task was important. (Einstein & McDaniel, 1990; McDaniel & Einstein, 2007). In Table 4 we can see that the performance over EB PM task is significantly better than that on TB PM task in both OT reward condition and no reward condition. Similarly, in table 7 we can see that the performance on EB PM task is again significantly better than that on TB PM task in both PMR and NR conditions. Figure 3 and 4 depicts that the bar of EB PM performance is consistently higher than that of TB PM performance irrespective of which task is rewarded. This clearly answers our first research question that the performance on EB PM task usually better than TB PM task. However, the interaction effect between reward condition and PM task type was not statistically significant. This provides an answer for our second research question that the difference between the performance of EB and TB PM task is not effected by the relative importance of PM task.

The superior performance on EB tasks aligns with a large body of evidence suggesting that EB tasks benefit from the presence of salient environmental cues that can spontaneously

trigger intention retrieval (McDaniel & Einstein, 2000; Scullin, McDaniel, & Einstein, 2010). By contrast, TB tasks rely more heavily on self-initiated monitoring processes such as time estimation and clock checking (Harris & Wilkins, 1982), which are resource demanding and more prone to failures (Block & Zakay, 2006). Thus, the present findings provide further empirical support for the multiprocess framework (McDaniel & Einstein, 2000), which posits that EB tasks can often be supported by relatively automatic retrieval processes, while TB tasks necessitate greater executive control and strategic monitoring.

Although rewards have been shown to modulate PM performance by increasing task motivation and attentional allocation (Kliegel, Martin, McDaniel, & Einstein, 2001; Walter & Meier, 2014), the current study found no significant interaction between reward condition and PM task type indicating that the relative benefit of EB over TB performance was stable regardless of the importance of tasks (OT or PM). This suggests that while importance of PM tasks may generally lead to enhanced engagement with the task environment, they did not differentially affect the relative advantage of EB over TB tasks. One possible explanation is that the cognitive demands intrinsic to TB tasks—particularly the requirement for self-initiated monitoring—may not be easily mitigated by external incentives. Even when motivated by reward, participants may still experience difficulties maintaining attention to elapsed time, thereby limiting the potential for performance improvements in TB conditions. Furthermore, the absence of an interaction effect might indicate that reward manipulation primarily influences overall task engagement rather than the underlying retrieval processes. That is, rewards may boost general attentional effort but cannot eliminate the fundamental cognitive differences between TB and EB tasks. This interpretation is consistent with prior work showing that motivational incentives enhance ongoing task performance more robustly than prospective remembering (Krebs, Boehler, & Woldorff, 2010).

The findings contribute to theoretical models of prospective memory by highlighting the robustness of EB task advantages across motivational contexts. This can have some useful implications regarding some everyday PM tasks like taking medicines on time. If the PM instructions are encoded and stored in a manner that they are embedded with some salient contextual cues rather than relying totally on time monitoring, it can improve the overall execution of a PM task.

CONCLUSION, LIMITATIONS AND FUTURE DIRECTIONS

In summary, the present study demonstrated that EB tasks were consistently associated with superior PM performance compared to TB tasks. Or, we can say that, it's easier to execute a PM task when it has been associated with some external environmental cue. This supremacy of EB paradigm over TB paradigm will hold irrespective of importance of the PM task. The motivational incentives alone are insufficient to eliminate the fundamental cognitive demands of TB prospective remembering. These findings highlight the need for interventions that combine motivational strategies with environmental supports to optimize prospective remembering in everyday life.

Some limitations of this study should be noted. First, the study did not examine the possible moderating role of individual differences, such as executive functioning capacity, which may influence the extent to which rewards impact TB and EB performance (Schnitzspahn, Stahl, Zeintl, Kaller, & Kliegel, 2013). Second, the reward structure may not have been sufficiently strong or personally relevant to fully capture motivational effects, and future studies could employ varied or more meaningful incentives. Finally, the study relied on

laboratory-based tasks, which may limit the ecological validity of the findings. Future research should investigate how motivational manipulations affect PM in naturalistic settings and whether combining rewards with external cues can improve TB performance.

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Conflict of Interest

The author(s) declared no conflict of interest.

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