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Research Paper

Looking at Time Based Prospective Memory Performance from the Lens of Clock Monitoring Behaviour

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ABSTRACT

Time monitoring is an essential component in a Time Based Prospective Memory Task (TB PM). This study aimed to find if clock monitoring can aid TB PM performance or not and how clock checking behaviour is effected by varying the importance of TB PM task. 120 participants in this study performed two blocks of computer based Ongoing Task (OT) and PM tasks. The participants were divided in two groups and were given TB PM task of different importance level (either OT was rewarding (N=70) or PM task was rewarding (N=50)). Both the group also performed in a controlled condition where neither OT nor PM task were rewarding. The participants could see the clock during the experiment by pressing "Ctrl" key on the keyboard. Obtained data was analysed using Wilcoxon Signed Rank test, Mann Whiteney U test, independent sample t-tests and Pearson's correlation coefficient. The results showed that clock checking was significantly higher when the PM task was rewarding as compared to when OT was rewarding. However, there was a significant correlation between clock monitoring and PM performance only when PM task was unimportant (0.440, $p<0.01$). When PM task was made important, there was no significant relation between PM performance of experimental and control group (0.162, ns). The study excluded personality factors that can effect clock monitoring behaviour and PM performance.

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

Prospective memory (PM) refers to the ability to remember to perform intended actions in the future (Einstein & McDaniel, 1990; McDaniel & Einstein, 2007). Within PM research, a distinction is drawn between event-based PM (EB PM), which involves remembering to act when a specific external cue appears, and time-based prospective memory (TB PM), which requires executing an intention at or after a particular time without explicit external prompts (Einstein et al., 1995; McDaniel & Einstein, 2000). Because time

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itself is not externally perceptible, TBPM relies heavily on self-initiated monitoring strategies, most notably clock checking, which allows individuals to align their internal sense of elapsed time with objective time (Harris & Wilkins, 1982; McDaniel & Einstein, 2011).

The study of TB PM offers insight into how people manage dual-task demands, balancing an ongoing activity while intermittently checking the time to ensure timely execution of delayed intentions. Classic studies demonstrated that clock checking increases markedly as the target deadline approaches, forming a “J-shaped” distribution (Harris & Wilkins, 1982). Recent evidence emphasizes that not only the frequency but also the strategic timing of clock checks predicts successful TB PM performance (Vanneste et al., 2016; Waldum & McDaniel, 2016). Moreover, neural evidence implicates the rostral prefrontal cortex (Brodmann Area 10) in coordinating attention between ongoing tasks and temporal monitoring, supporting theoretical accounts of prospective control (Burgess et al., 2003; Cona et al., 2015).

Clock-checking strategies are sensitive to several task parameters. Shorter deadlines elicit denser late-interval monitoring, whereas multiple or uncertain deadlines promote earlier and more distributed checking (Harris & Wilkins, 1982; Waldum & McDaniel, 2016). The difficulty of the ongoing task also shapes monitoring: higher cognitive load reduces opportunities for checking, often leading participants to cluster checks during task transitions (Einstein et al., 1995). Moreover, digital platforms that record check latencies in real time have allowed researchers to examine fine-grained features such as the last-check-to-deadline interval, providing more precise predictors of TB PM success (Vanneste et al., 2016).

Given the centrality of monitoring processes, clock checking provides a unique behavioral window into the mechanisms underlying TB PM. As per multi-process view (McDaniel & Einstein, 2000), a person can employ either automatic or strategic processing for execution of a PM task. Automatic and strategic processing are related to maintenance of retrieval intention in the mind. Individuals using strategic processing dedicate specific attentional resources for PM cue monitoring and they will keep scanning the environment very frequently for this cue, (or in case of TB PM task, critical moment to execute the PM intention). On the other hand, the individual using automatic processing doesn’t dedicate any specific attentional resource for environment monitoring. Instead, the PM intention pops up automatically in their minds at regular intervals and then they scan the environment for the cue.

In the present study, the researchers tried develop an OT which doesn’t consist of only a single type of task like lexical decision (Albiński,, Kliegel, and Gurynowicz, 2016; Meier and Zimmermann, 2015; Scullin et al, 2010) or card sorting task (Sheppard et al, 2015). This was done to induce variety in the OT, as it is present in our daily life. Secondly, the tests in this experiment are of a longer (two blocks of 20 minutes each) rather than just few minute task. This was done so that laboratory tasks can more closely mimic PM tasks of day to day life thus increasing the generalisability of the experiments. Finally, researchers in this study tried to look at the TB PM task performance by analysing the frequency of clock checking during the experiments. In day to day life, clock monitoring is a pre requisite for successful execution of any TB PM intention. Analysing clock checking frequency can give much insight into the underlying processes.

In the present study, researchers tried to the answer following questions:

a) Can clock checking behaviour aid to successful performance of TB PM task?
b) Does importance of TB PM task have any effect on person's clock checking tendency?

The Paradigm of Current Study:
The current study follows a paradigm that has been used previously and frequently by other studies for measuring TB PM. As per the paradigm, participants are asked to perform an ongoing task (OT), which may be a lexical decision task, stroop test, word classification task, card naming task etc. The candidates have to perform prospective memory (PM) tasks at some specified interval (in case of TB PM Task) or on occurrence of a particular target cue (in case of EB PM task) during the OT. The PM task may include signing a form at the end of the test or pressing a specified button on the keyboard etc. The conditions for execution of the PM task (i.e. the specified interval or the target cue) is explained to the participants 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).

The current study used computerized testing format for which a software was specifically developed by the team. The team had also developed a set of questions that would be given to candidates as an OT.

The PM task and the questions of OT were based on similar PM studies done in past. The specific OT and PM used in this study have been explained in Material section of this paper.

METHOD

Sample:
In this study the researchers selected those participants who were currently involved in preparation of some competitive exams, or academic exams preferably in the age range of young adults. This was done to ensure that the OT doesn't look boring to the candidates. Following table gives a description of the sample used in this study:

Block	Total Sample	Discarded Sample	Valid Sample	Minimum Age (Valid Sample)	Maximum Age (Valid Sample)	Average Age (Valid Sample)
OTR-NR	96	26	70	18	27	21.73
PMR-NR	52	2	50	18	29	23.02
Overall Total	148	28	120	18	29	21.97

The data of 28 candidates had to be discarded because either they had shown retrospective error (20 candidates) or the software failed to record the clock checking data (8 candidates)

Materials:
Ongoing Task:
The ongoing task designed for this study included basic objective reasoning type questions. These questions were based on the OTs used in previous studies (lexical decision task-Einstein et al, (1990), Smith (2003); semantic/category judgement task-Meir et al (2000),

Marsh et al (2002); perceptual/colour matching/ feature matching task- Meier et al (2006), Scullin et al (2010); arithmetical problems- Einstein et al (1996)). However, the difference was that, in previous experiments, the studies used single type of task throughout the whole experiment. In current study, the researchers combined multiple tasks, formulated them in form of logical questions and presented to the candidates as OT. Making these modifications made the OT more interesting, and indulging.

The logic of each question was already mentioned in the question. The participant just had to apply that logic to solve the questions and select the correct option. This was done to ensure that the candidates who are slow in solving such questions do not feel discouraged.

The questions developed for this study were validated by administering them on 5 demo candidates of similar age and qualifications. The duration of presentation of each question was also ascertained based on this demo administration.

Each participant had to complete two blocks of OT. Each block was of 20 minutes and had 50 questions. Each question was presented on the screen for 24 seconds. Within this time, the candidates had to solve the question and mark the correct option. In real test, the candidates were not aware of this timing. They were told that question will automatically change after some time.

Prospective Memory Task:
In each block of 20 minutes, there were 4 instances of PM task. The PM task was to record the question numbers participants were doing exactly at the end of 5th, 9th, 15th, and 19th minute, i.e. specifically at 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 response made in this window will be considered correctly. The questions were numbered in a jumbled and unusual way using 3 or 4 digit numbers. Also, the questions were not presented in a serial order to prevent guessing by the participants. To perform the PM task, i.e. recording the question numbers, participants had to press “Alt” key on the keyboard and record their response in a new window appearing on the screen after pressing Alt key.

In previous studies, most used TB PM task is pressing a particular button on keyboard at a particular interval (Harris et al (1982); Einstein et al (1995)) or at specific clock time (Leitz (2009); Ballhausen (2017)). The researchers in this study used a similar task with a little modification. Here, in addition to press a button, the participants were also required to record the question number they were doing at that time. This made the PM task a little more complicated which is the case in our day to day life.

To see the clock, the participants can press “Ctrl” button on the keyboard. Once “Ctrl” button is pressed, a clock appeared on the screen for 3 seconds and showed the exact time elapsed since the test block has started.

Manipulating relative Importance of Prospective Memory Task:
The relative importance of PM task was manipulated by either rewarding PM task performance or rewarding OT performance or either giving no reward for any task. The reward was that top three performers will be given Amazon Voucher.

Research Design:
The study had two groups of participants. Both the groups completed two blocks of 20 minutes each. For Group 1, in one block OT was rewarding and in other block, no reward was given (also referred as OTR-NR block pair). For Group 2, in one block PM task was rewarding and in other block, no reward was given (also referred as PMR-NR block pair).

	Block 1 (20 minutes)	**Block 2(20 minutes)**
Group 1 (OTR-NR Block Pair) (n=70)	Ongoing Task Rewarded	No Reward
Group 2 (PMR-NR Block Pair) (n=50)	PM Task Rewarded	No Reward

The details of PM task, OT and reward condition were clearly and explicitly mentioned in the instructions before each block.

Procedure:
The candidates were seated in front of the screen. They were explained briefly about the testing procedure and approximate time required. Once they gave their consent in the software, they were directed to a home screen of the test. At the home screen, the candidates first selected the Instructions for Block 1. After understanding the instructions, they were then asked to select the "Example" option. There 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. Once they were comfortable, they were asked to start the Block 1 testing.

After completion of Block 1 testing, the candidates selected Instructions for Block 2. Once they understood the instructions, they were asked to start Block 2 testing.

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 end of each block, 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?

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

After completion of whole testing procedure, the candidates were explained about the purpose of this test and thanked for their participation.

RESULTS

For the analysis of clock monitoring behaviour, whole block of 20 minutes was divided in 20 equal intervals of 1 minutes each (0-1, 1-2, ……… 19-20). Average clock checking frequency in each interval was recorded. This was calculated by the number of times "Ctrl" button was pressed in each interval by all the participants.

Wilcoxon Signed Rank Test and Mann Whitney U test has been performed to check the difference between Clock monitoring frequencies. Pearson's coefficient of correlation has been calculated to check the relation between clock monitoring and PM performance. Independent sample t test has been performed to analyse the difference in performance of PM task of those participants using strategic and automatic processing.

Table 1: Average clock checking frequency per individual for every minute of OTR-R[1], OTR-NR[2], PMR-R[3], PMR-NR[4]

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
OTR-R	0.61	1.06	0.86	1.20	2.51	1.34	1.14	1.63	2.30	1.03
OTR-NR	0.54	0.71	0.80	1.13	1.89	1.40	1.16	1.46	2.61	1.39
PMR-R	0.70	1.38	1.40	2.44	4.78	1.76	1.76	2.40	3.84	1.62
PMR-NR	0.60	0.92	1.06	1.48	3.90	1.32	1.26	1.78	4.28	1.48

	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20
OTR-R	1.27	1.27	1.27	1.99	2.56	1.00	1.24	1.40	2.37	1.49
OTR-NR	1.27	1.31	1.27	1.53	2.67	1.23	1.30	1.76	3.21	1.60
PMR-R	2.24	2.24	2.04	2.54	4.18	1.46	1.88	2.34	5.10	1.48
PMR-NR	1.52	1.60	1.80	2.34	3.82	1.76	1.64	2.22	3.98	1.52

1- Reward Block of OTR-NR block pair, 2- No-Reward Block of OTR-NR block pair
3- Reward Block of PMR-NR block pair, 4- No-Reward Block of PMR-NR block pair

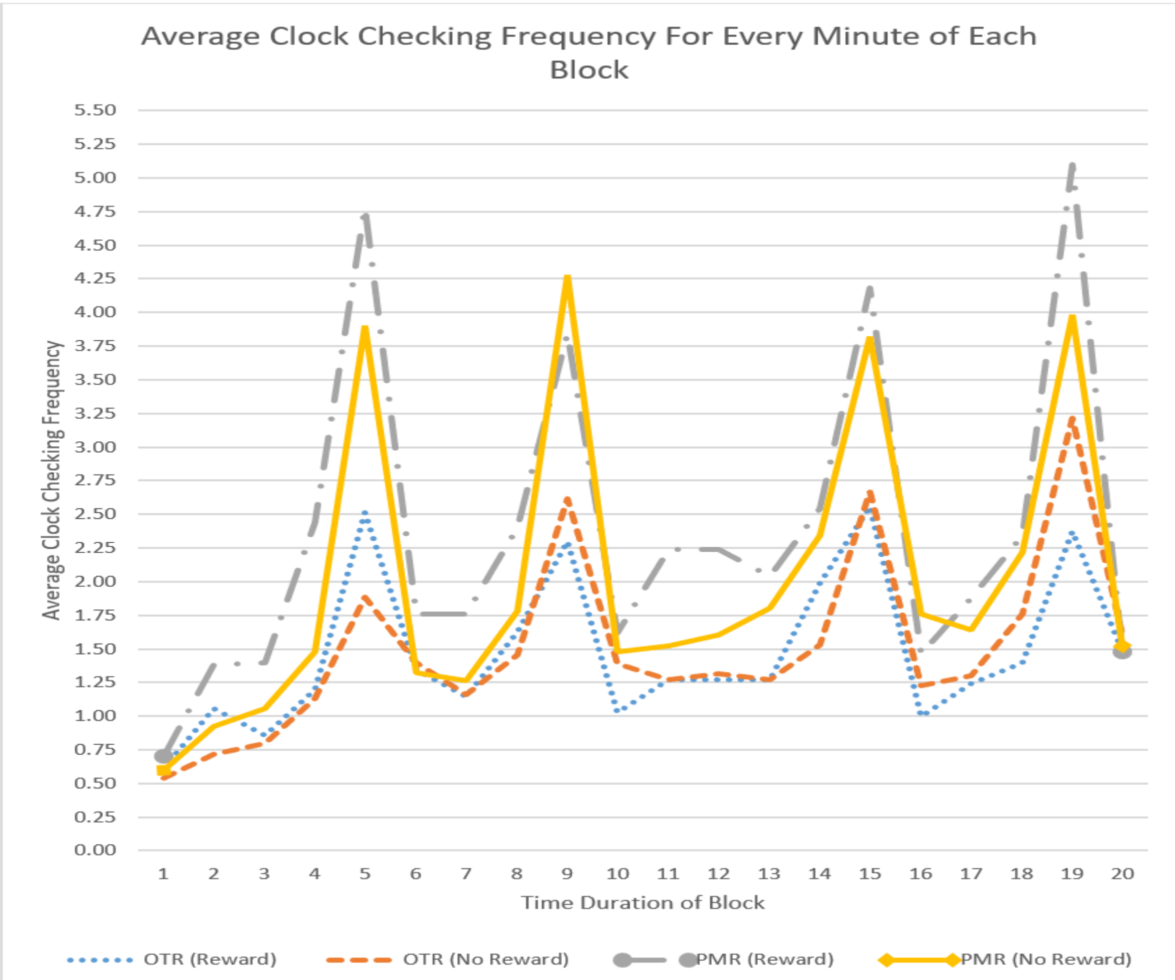

Fig 1: Showing graph of average Clock checking frequency in every minute of each block OTR-NR pair (n=70) and PMR-NR pair (n=50)

Table 1 and Figure 1 shows that average clock checking frequency per individual was highest when PM task was rewarding and lowest when OT was rewarding. For all conditions, clock checking frequency shot sharply in 5th, 9th, 15th, and 19th minute which were the moments of PM task.

Comparing Clock Checking Frequency Between Reward and No Reward Condition:

Table 2: Wilcoxon Signed Rank Test for Comparing Clock Checking Frequency in Reward and No Reward Blocks of OTR-NR Pair and PMR-NR Pair

Condition	Block	Significance Level	Result
Group 1 OTR-NR Block Pair (N=70)	OT Reward Block No Reward Block	0.435	Retain Null Hypothesis
Group 2 PMR-NR Block Pair (N=50)	PM Reward Block No Reward Block	0.012	Reject Null Hypothesis

Table 2 show that in OTR-NR Block Pair, mean clock checking frequency there was no significant difference between clock checking frequency between reward (OT Reward) and no reward condition.

Whereas in PMR-NR Block Pair, mean clock checking frequency in a block was significantly higher when PM performance was rewarded as compared to when no reward was given.

Table 3: Mann Whitney U test for comparing Clock Checking Frequency in PM Reward Block of Group 1 (n=50) and OT Reward Block Group 2 (n=70) and No Reward Blocks of Group 1 and 2

	M-W-U	Z	Significance
(PMR Block of Group 2) - (OTR Block of Group 1)	1042	3.770	0.0000
(NR Block of Group 2) - (NR Block of Group 1)	1222	2.811	0.005

Table 3 show that mean clock checking frequency in a block was significantly higher when PM performance was rewarded as compared to when OT performance was rewarded. Similarly, mean clock checking frequency was significantly higher in no reward block of PMR-NR pair (Group 2) as compared to no reward block OTR-NR pair (Group 1)

Analysing Relation Between Clock Checking and PM Task Performance:

Table 4: Correlation Between Clock Checking Frequency and PM Performance in OT Reward and No Reward Blocks of OTR-NR Pair (Group 1)

	Clock Checking Frequency in OT Reward Condition	**Clock Checking Frequency No Reward Condition**
Total PM Score in OT Reward Condition	0.440 (p=0.000)	-
Total PM Score in No Reward Condition	-	0.388 (p=0.001)

Table 4 shows that in OTR-NR pair, significant correlation exists between clock checking frequency and PM performance in respective block.

Table 5: Correlation Between Clock Checking Frequency and PM Performance in PM Reward and No Reward Blocks of PMR-NR Pair (n=50) (Group 2)

	Clock Checking Frequency in PM Reward Condition	**Clock Checking Frequency No Reward Condition**
Total PM Score in PM Reward Condition	0.162 (p=0.260)	-
Total PM Score in No Reward Condition	-	0.002 (p=0.987)

Table 5 shows that in PMR-NR pair, no significant correlation exists between clock checking frequency and PM performance in respective block.

Analysis of Automatic and Strategic Processing:
In the current experiment, the clock monitoring frequency per minute has been recorded for each block. For the analysis of strategic or automatic processing, the interval of $4^{th} – 5^{th}$, $8^{th} – 9^{th}$, $14^{th} – 15^{th}$, and $18^{th} – 19^{th}$ were excluded. The rationale behind this is that these slabs were the slabs of PM task. So, once the individual comes to know that the time for PM task execution is approaching, he or she is likely to monitor clock very frequently irrespective of the type of processing he or she is employing.

Out of remaining 16 slabs, the individuals who has not monitored clock in 50% of the slabs (i.e. 0 monitoring in 8 slabs) were considered to use Automatic processing. Otherwise, they were classified as using strategic processing.

Table 6: Number and Percentage of Individual Employing Strategic and Automatic Processing in Reward and No Reward Blocks of OTR-NR and PMR-NR Pairs

Block Pair / Group	**Reward Condition**	**No. of Individual Employing Automatic Processing (%)**	**No. of Individual Employing Strategic Processing (%)**
Group 1- OTR-NR Pair (n=70)	Ongoing Task Rewarded	28 (40%)	42 (60%)
	No Reward	28 (40%)	42 (60%)
Group 2- PMR-NR Pair (n=50)	PM task Rewarded	10 (20%)	40 (80%)
	No Reward	10 (20%)	40 (80%)

From table 6 it can be seen that in OTR-NR pair (Group 1), 40% (28) individuals employed automatic processing and 60% (42) individuals employed strategic processing. This data was same whether OT was rewarded or whether no reward was given.

Similarly, in PMR-NR pair (Group 2), 20% (10) individuals employed automatic processing and 80% (40) individuals employed strategic processing. This data was same whether PM was rewarded or whether no reward was given.

Table 7: Processing Consistency Across Reward and No Reward Blocks in OTR-NR and PMR-NR Pairs

Condition	**No. of Participants Employing same Processing Strategy**	**% of Participants Employing same Processing Strategy**
OTR-NR pair (n=70)	56	80%
PMR-NR pair (n=50)	42	80.4%

Table 7 shows that 80% (56) individuals in OTR-NR and 80.4% (42) individuals in PMR-NR pair employed same processing strategy irrespective of whether there was any reward (for OT in OTR-NR pair and for PM task in PMR-NR pair) or not

Comparing PM Performance in Strategic and Automatic Processing:
Each block of both the groups had four instances of TB PM task. Thus, in each block, maximum score for a participant can be 4 and minimum can be 0.

Table 8: Mean and SD of PM Performance of Individuals Employing Automatic and Strategic Processing in Reward and No Reward Blocks of Group 1 and 2

Group	**Reward Condition**	**N (Automatic Processing)**	**Mean (SD) for Automatic Processing**	**N (Strategic Processing)**	**Mean (SD) for Strategic Processing**
Group 1- OTR-NR Pair (Total N=70)	Ongoing Task Reward Block	28	0.61 (1.197)	42	1.86 (1.539)
	No Reward Block	28	1.57 (1.317)	42	2.29 (1.384)
Group 2- PMR-NR Pair (Total N=50)	PM Task Reward Block	10	2.40 (1.350)	40	3.15 (1.001)
	No Reward Block	10	2.20 (1.398)	40	2.55 (1.319)

Table 9: Independent sample t test for comparing PM Performance of individuals using Strategic and Automatic Processing in Reward and No Reward Blocks of Group 1 and 2

Group	**Reward Condition**	**Comparison Groups**	**Avg Mean Difference**	**SEM (D)**	**t**	**df**	**Sig**
Group 1- OTR-NR Pair (Total N=70)	Ongoing Task Reward Block	(PM_Strategic) - (PM_Automatic)	1.250	0.345	3.625	68	.001
	No Reward Block	(PM_Strategic) - (PM_Automatic)	0.714	0.331	2.156	68	0.035
Group 2- PMR-NR Pair (Total N=50)	PM Task Reward Block	(PM_Strategic) - (PM_Automatic)	0.750	0.380	1.973	48	.054
	No Reward Block	(PM_Strategic) - (PM_Automatic)	0.350	0.472	0.742	48	0.462

Tables 8 & 9 show that in case of Group 1 when either OT was rewarded or no reward was given, the performance of individuals employing strategic processing for completing the PM task was significantly better than the performance of those individuals who relied on automatic processing. When OT was rewarding, this difference was significant (t=3.625) at 0.01 level whereas when no reward was given, this difference was significant (t=2.156) at 0.05 level. However, in case of Group 2 when either PM task was rewarded or no reward was given, there was no significant difference between the performance of individuals employing strategic processing or automatic processing for completing the PM task.

DISCUSSION

The study aimed to see if clock monitoring is helpful for TB PM task or not? Secondly, the study wanted to see, how manipulating the relative importance of TB PM task effects a person's clock monitoring behavior?

Figure 1 in the result section shows a curve which resembles a "J Shaped curve" as seen by Harris and Wilkins, 1982 [Gan and Guo (2019) and Guo and Huang (2019)]. If the graph is divided in four parts (each part corresponding to the period of one PM task), then for each part, a curve resembling J-shaped can be seen. As the time for execution of PM task approached, the clock checking frequency suddenly rose and as soon as that time is over, the frequency dropped. This was the general pattern seen in all the conditions of both group 1 and 2 (i.e. OTR-OT Reward, OTR-NR, PMR-PM Reward, PMR-NR). The curves obtained in this study supports the Test-Wait-Test-Exit Loop described by Harris and Wilkins. The candidates execute multiple test-wait cycle until the PM execution time is near. Once, the deadline is close they execute test-execute cycle and then exit. In the current experimental condition, this loop was executed four times in each block.

Looking at the lines of different reward conditions in Figure 1, it can be seen that the lines of group 2 (PMR-NR block pair) is clearly higher than that of group 1 (OTR-NR block pair). This was the trend throughout, barring a few instances. These exceptions were usually at the beginning of the block or immediately after the execution of TB PM task. In fact, at the beginning or after execution of the TB PM task, all four lines clustered at the bottom of the graph showing that the clock monitoring has suddenly reduced. This shows that after the execution of one TB PM instance in the block, importance of all the PM tasks becomes equivalent whether they are rewarded or not. It is only when the next instance of TB PM task approaches, the importance of PM task shows its effect and the lines start getting separated. Thus, relative importance does seem to have an effect of clock checking behavior, but this effect becomes more prominent as the critical time for execution of PM task approaches.

This was tested using Wilcoxon Signed Rank test and Mann Whitney U test. Firstly, the difference between two conditions of within each group (i.e. Group 1- OTR-NR pair and Group 2- PMR-NR pair) were tested using Wilcoxon Signed Rank test (table 2). Then Mann Whitney U tests were performed to see the difference between (i) OTR and PMR conditions (table 3) and (ii) NR conditions of both the groups (i.e. NR condition of OTR-NR Pair and NR condition of PMR-NR pair) (table 3). It was found that in Group 2 (PMR-NR block pair), clock checking frequency was significantly higher when PM task was rewarding as compared to when no reward was given for any task but this difference between clock checking frequency in OT reward condition and no reward condition was not significant in Group 1 (OTR-NR pair) (table 2). In fact, the mean clock checking frequency for group 1 was almost equal irrespective of whether OT was rewarded or whether No reward was given for any task (table 2). In figure 1, the lines showing mean clock checking frequency in group 1 are running very close to each other and they are frequently crossing each other. These findings are consistent with motivational accounts of prospective memory, which propose that when the importance of a PM task is emphasized—whether through social relevance or monetary incentives—participants increase their monitoring efforts to secure successful performance (Walter & Meier, 2017). It also aligns with evidence showing that clock checking is a reliable behavioral indicator of monitoring and predicts better TBPM performance when participants assign high subjective value to remembering (Mioni et al., 2020). Whereas, when OT is more important, the monitoring becomes costly, individuals reduce their checking frequency, even at the expense of TBPM performance (Zuber et al., 2024). The clock checking frequency when PM task was rewarding was significantly higher than that of when OT was rewarding (table 3). Also, the clock checking frequency in No reward block of PMR-NR pair was significantly higher than that in No reward block of OTR-NR pair (table 3). This gave few insights about clock checking behavior while doing a PM task, First, the clock monitoring will be frequent when the PM task will be rewarding and it will be very less when OT was rewarding. This answers our second research question that "Yes, manipulating the relative importance of PM task does have an effect on clock checking behviour with more important PM task eliciting frequent clock checks". Second, and more interesting, in terms of clock checking behavior, the NR Reward block of each pair behaved as per its other counterpart in the pair, i.e. when PM task was rewarding, the clock checking remained comparatively higher even when the task was made no rewarding. Similarly, when the OT was rewarding, the clock checking remained less frequent even when the OT was no more rewarding. This shows that once the PM task has been tagged with a particular level of importance, this tag persists and keeps effecting the retrieval of PM intention even after its importance level has changed. This can have practical implications. If, an importance tag has been attached to the TB PM intention while encoding, it is more likely to be recalled at the critical moment even though that tag fades with time.

To check if there is any relation between clock monitoring and successful performance of TB PM task, correlation between clock checking frequency and TB PM task performance was calculated. In table 4, the Pearsons coefficient of correlation between TB PM task scores in group 1: when OT was rewarding or when No reward was given; with the clock checking frequency in the respective blocks was 0.44 and 0.388. These values are highly significant. Similarly, in table 5, the coefficient of correlations between TB PM task scores in group 2: when PM task was rewarding or when No reward was given; with the clock checking frequency in the respective blocks was 0.162 and 0.002. These values were too low to achieve any level of significance. Thus, it can be observed that the control conditions (no reward block) of each group behaved as the experimental condition of the respective group (OT Reward or No Reward) as far as clock monitoring behavior is concerned. These results strengthen the previous findings that once the TB PM task is labelled with a particular level of importance, it continues to effect its retrieval even if the tag has been removed or changed. Additionally, these results show that the clock monitoring would correlate with PM performance till the PM task is not important. Once PM task is made important, the clock monitoring doesn't show any relation with PM performance. These findings are consistent with resource-competition accounts of TB PM, which emphasize the interference between ongoing task demands and prospective monitoring (McDaniel & Einstein, 2000). When the ongoing task was incentivized, the resource demands of that task likely suppressed TB PM performance unless participants deliberately allocated attention to time monitoring, thereby strengthening the link between clock checking and remembering.

The results can be interpreted in light of the Expected Value of Control (EVC) model, which posits that cognitive control is deployed to maximize the subjective value of competing tasks (Shenhav et al., 2013). When the TBPM task carried direct rewards, motivation to remember was high across participants, potentially reducing variability in monitoring and producing a ceiling effect in performance. Under such circumstances, factors beyond sheer monitoring frequency—such as strengthened goal maintenance or intention rehearsal—may have contributed to successful remembering, thereby weakening the monitoring–performance correlation (Walter & Meier, 2017). In contrast, adding reward to OT creates a cost-benefit tradeoff between devoting resources to OT or clock checking for PM task. Adding costs to clock monitoring reduces clock monitoring frequency and also TB PM performance (Zuber et al 2024). Thus, only those participants who engage in intentional clock monitoring performs well on TB PM task.

These results have answered our other research question. Clock monitoring improves TB PM performance only when OT is more important as compared to PM task. As soon as we increase the importance of PM task, multiple other factors may contribute to its successful performance and clock monitoring becomes redundant or may be less prominent.

Based on the clock monitoring behavior, the study also tried to evaluate the type of processing employed by the participants. The methodology adopted for distinguishing between strategic and automatic processing has already been explained in results section. Before discussing these results it is made clear that, the research team's decision to use this methodology was based on internal discussion among team members. The authors are ready to accept and reanalyze the data if any other and logically sounder methodology is available.

Table 6 shows that in group 1 (OT Reward and No reward block pair) 40% of individuals employed automatic processing whereas 60% individuals employed strategic processing. In group 2 (PM reward and No reward block pair), 20% individuals employed automatic processing whereas 80% individuals employed strategic processing. This gives us insight that importance of PM task effects the type of processing. More important PM task will mandate strategic processing. The number of individuals using strategic and automatic processing in control condition of each group (No reward block) are same as the number of individuals using strategic and automatic processing in experimental condition of the respective groups (i.e. OT Reward block in group 1 and PM reward block in group 2) (table 6). Thus, in OTR-NR group 40% participants used automatic processing and 60% participants used strategic processing in both OTR and NR blocks. Similarly, in PMR-NR group 20% participants used automatic processing and 80% participants used strategic processing in both PMR and NR blocks. This consistency again strengthened the assertion that once the PM task has been tagged with a level of importance, its effect persists even when the importance level has changed. The results are can be explained by Shehnav's (2013) Expected Value of Control model which states that allocation of monitoring resources is according to the payoff.

The results further encouraged us to see how many individuals changed their processing strategy from reward to no reward condition in a group? Table 7 shows that in both the groups around 80% participants have shown processing consistency. I.e. the type of processing (automatic or strategic) used by a person in no reward condition was same as it was in the reward condition (OTR or PMR) of that group. Thus, it can be concluded that using a particular type of processing is not just a function of task importance. Probably the personality of person also effects the type of processing he or she employs. In other words, clock monitoring can be said to represent a relatively stable trait-like characteristics (Zuber et al, 2022). At the same time, the 20% of participants who shifted between processing modes across conditions highlight the role of context-sensitive flexibility. This subgroup illustrates that, although many individuals rely on a stable approach, a minority can adjust processing depending on incentives and task demands, in line with adaptive control theories of prospective memory (Zuber et al., 2024). However, testing this conclusion remains out of the purview of this paper.

Based on type of processing employed by a candidate, the difference in their TB PM performance was also assessed. Table 9 showed that in group 1 (OTR-NR block pair) the participants using Strategic processing performed significantly better than the candidates relying on automatic processing. The results remained same for both OT reward block and no reward block. Similarly, looking at table 9, it can be inferred that in group 2, there was no significant difference between performance of candidates using strategic processing and candidates relying on automatic processing. Again here, the results were same for both PM reward block and no reward block. This again provides support to two of our previous conclusions: First, the effect of importance tag persists even when it has been removed. Second, when the PM task becomes important, type of processing is not just the only factor that effects performance. These results explain the motivational incentives and resource allocation in a PM task. When PM task was made rewarding, participants may prioritize the PM task itself, reducing the reliance on additional monitoring strategies. Consistent with previous work on motivational incentives and prospective memory (Walter & Meier, 2014; Meier & Zimmermann, 2015), reward-related attentional focus may facilitate performance even in the absence of explicit strategic monitoring. Thus, when the PM task holds intrinsic value due to reward contingencies, both automatic and strategic processes appear to support performance to a comparable extent. However, one additional way of explaining non-significant difference in group 2 could also be that only a small number of participants relied on automatic processing (n=10) as compared to those using strategic processing (n=40). This might have affected the statistical computations and produced a non-significant t value. But this needs to be tested by increasing the sample size.

CONCLUSION AND LIMITATIONS

The study has provided an answer to both of our research questions. Increase in clock monitoring improves our PM performance however, this trend follows till the time PM task in unimportant. As soon as PM task is incentivized, clock checking may not be the only factor that effects performance. Secondly, increasing the importance om a TB PM task increases the clock checking behavior making the person rely more on strategic processing. Also, it was seen that the importance tag associated with the PM task persists even after that tag has been removed. This could have practical implications in improving the performance on crucial PM tasks in daily life. Inculcating clock monitoring behavior for (seemingly) unimportant tasks can help in improving the performance on daily life PM tasks some of which can be extremely critical like taking medicines on time.

This study has also given a hint that there are other individual level differences that may be effecting the successful performance of TB PM task. May be there are some personality traits due to which a person is inclined towards choosing a particular processing strategy. However, since there were no personality questionnaires included in the study, this remains one of the major limitation of this study which needs to be addressed in future studies.

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Conflict of Interest
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