Effects of Target Salience and Task Importance on Prospective Memory and its Prospective Interference in Low and High Achieving Pupils in Math*

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Abstract Some studies have shown that low achieving pupils, especially low achievers in math report more prospective memory (PM) failures than high achievers. To explore how to improve their PM performance, and how target salience and task importance of PM affect PM performance in low achievers in math, the effects of target salience and task importance on PM and prospective interference were compared between low and high achieving pupils in math in the present study. Target salience (PM tasks with salient target vs. PM tasks with non-salient target) was manipulated as a within subject factor, and task importance of PM (importance emphasized vs. no emphasis) and achieving group (low vs. high achieving pupils in math) as between subject factors. Furthermore, to examine prospective interference to the ongoing task, every participant completed a set of baseline tasks without PM. The results suggestted that high achieving pupils outperformed low achieving pupils in PM tasks. Salient targets improved PM performance. But emphasizing PM importance improved PM accuracy only in non-salient PM condition. According to the results, it is important to help low achievers to establish a salient target for their PM tasks. If the target can't be salient, then emphasizing the importance of the PM tasks。

Key words event-based prospective memory, low and high achieving pupils, target salience, task importance, prospective interference effect

1 Introduction

Prospective memory (PM) is the memory for intended actions to be performed at the appropriate time or situation in the future. Event-based PM refers to intended actions to be performed when some external events occur. For example, to remember to do one' s homework when seeing one's school bag, to remember to discuss something when meeting someone. Forgetting to carry out an intention as planned may cause serious consequences to one's daily life.

PM affects not only individual's daily life, it may also affect individual's academic performance. Some studies have shown that PM is significantly related to academic achievement. Low achieving pupils, especially low achievers in math report more PM failures than high achieving pupils (Chen, Liu, Wang, Shum, & Chan, 2014). They are prone to forget to do their homework or something teachers tell them to do which influence their study. Furthermore, results from behavior studies (Chen, Lian, Yang, Liu, & Meng, 2017; Dong, Zhou, & Guo, 2008) and an ERPs (event-related potentials) study (Ji, 2012) also showed that low achieving pupils were weak at PM at least in some situations. But only few studies have examined what influence PM performance in low achieving pupils (Chen et al., 2017; Dong et al., 2008). Dong et al. (2008) compared the effects of cognitive styles and reminders on different kinds of PM between low achieving pupils and average achieving pupils, results showed that: (1) Reminders can facilitate the performance of low achievers in time-based prospective memory tasks and the PM performance of low achievers is not as good as that of normal children in time-based prospective memory tasks without reminders; (2) The field-independent subjects performed better in event-based prospective memory tasks than the field-dependent subjects. Chen et al. (2016) explored the effects of working memory demand and reminders on PM performance in low and high achievers in math, results

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showed that high working memory load influenced more on low achieving students than on high achieving students. Yet our knowledge about the influencing factors and cognitive mechanisms of PM in low achieving pupils is still limited. No study has examined the effect of task importance and target salience on PM performance in low achieving pupils, but these two factors are important factors through which individuals can improve their PM. So in the present research, we aimed to explore how task importance and target salience influence PM performance and the underlying cognitive process in low achieving pupils compared with high achievers in math. The way to explore the underlying cognitive process of PM is to examine the prospective interference to the ongoing tasks from PM. Thus, we reviewed and examined how task importance and target salience influence PM performance and prospective interference.

1.1 Effect of task importance and target salience on PM

Some studies have investigated the influence of importance emphasis on PM performance in general population but not in low achieving pupils. The importance of PM tasks was created by providing a reward, relative importance instructions or absolute importance instructions (Rummel, Smeekens, & Kane, 2016). Some studies suggested that PM performance in a reward condition was improved compared to a no reward condition (Walter & Meier, 2014). But the enhancing effect of importance emphasis did not occur in all circumstances. For example, previous study (Einstein et al., 2005) has compared the effect of task importance on PM performance in a focal and a non-focal PM target condition (i.e., concurrent overlap, see Meier & Graf, 2000). The results showed that stressing importance influenced PM performance only in the non-focal condition but not in the focal condition. And this study demonstrated that focal target enhanced PM performance and caused less interference to the ongoing tasks compared to non-focal target. Similarly, some studies also indicated that salient target improved PM and had less interference to the ongoing tasks compared to non-salient PM target (Trawley, Law, Brown, Niven, & Logie, 2014). These studies showed that target salience and target focus (focal vs. non-focal target) affected PM and prospective interference in the same way. So we predicted an interaction between target salience and task importance on PM performance. That target salience benefited PM performance was also observed in young school children of 6~7 and 9~10 years old (Kliegel et al., 2013) and in a more ecologically valid environment (Trawley et al., 2014). So we predicted target salience would improve PM for all pupils.

1.2 Effect of task importance and target salience on prospective interference effect

Examining prospective interference effect is an important way to explore processing mechanisms underlying PM. If possessing a PM task requires processing resources, it should reveal task interference effect on ongoing activities (Lourenço, 2013). It is in dispute whether possessing PM intention causes task interference to ongoing tasks (Chen, Huang, & Yuan, 2010). According to the multiprocess view (Einstein et al., 2005), PM target detection will be automatic when one or more of the following conditions are met: the target and the to-be-performed target action are highly associated, the target is salient, or the ongoing task focuses attention on relevant features of the target. Otherwise, target detection can require significant processing resources. That is, whether a task interference effect exists depends on specific conditions. The preparatory attention processes and memory processes model (PAM) argues that even under those conditions where target detection should be automatic based on the multiprocess view, possessing an intention creates a cost manifested in the ongoing activity itself (Smith, 2003; Smith & Bayen, 2004). Preparatory attention processes occur prior to the occurrence of targets. Therefore, when a PM task is embedded in an ongoing task, the resources available for the ongoing tasks will be reduced, even when the target is not present.

Previous studies have showed that non-salient PM targets produced more interference to ongoing tasks compared to salient PM targetsis (Chen, Huang, Jackson, & Yang, 2009). The less salient the PM targets, the more cognitive resources may be required, and the more interference would be produced to the ongoing tasks. PM tasks with importance emphasis also produced more interference to ongoing tasks compared to PM tasks without importance emphasis (Smith & Bayen, 2004; Walter & Meier, 2014). Einstein et al. (2005) has also found that the importance and focal vs. non-focal PM target had an interaction effect on prospective interference. But no study has investigated the interference from PM in low achieving pupils compared with high achieving pupils. In this study, the task interference effect from PM was explored to examine the cognitive processes underlying PM in low achieving pupils compared with high achieving pupils.

2 Methods

2.1 Participants

Participants were selected from an elementary school (grade 4 and 5). The informed consent was provided by their parents before the experiment. First, we collected pupils’ scores of their math tests in the latest midterm and final examination. The test papers compiled and administered by their grade' s teachers and were the same for each grade. According to some studies (Cai, Li, & Deng, 2013; Zhou, 2012; Zhou, 2008) and the opinions of the math teachers, pupils who scored above the 20th percentile in their grade were considered as high achieving pupils and who scored below the 20th percentile were considered as low achieving pupils. In this study, pupils who performed above or below the 20th percentile on both tests were chosen as high or low achievers in math. Further confirmation of high and low math achieving status was confirmed by the pupils’ classroom teacher and 3 pupils were eliminated. Finally, 59 pupils were identified as high achieving group, and 52 pupils were identified as low achieving group. Their performances were in the normal range on standardized intelligence tests (Raven's Standard Progressive Matrices of China version revised by Zhang & Wang, 1989). Some pupils’ response accuracy of ongoing tasks (simple 1-back tasks) was lower than 0.6, as they misunderstood the tasks or didn’t take the tasks seriously. So these data were trimmed and only 95 data were valid. The intelligence score and demographic characteristics of the valid participants were showed in table 1.

2.2 Materials and procedure

2.2.1 Materials

The stimuli were 26 letters of the English alphabet displayed in uppercase letters. Letter “D” was used as the PM target.

2.2.2 Design and Procedure

Table 1. Intelligence score and demographic characteristics of two achieving groups

	Numbers		Age		Intelligence	
	Male	Female	*Mean*	*SD*	*Mean*	*SD*
HA	23	29	11.62	1.57	49.69	45.21
LA	24	19	11.49	1.72	3.95	3.97

Note. HA=high achieving pupils; LA =low achieving pupils. The same below.

A 2 (achieving group: high achievers in math, low achievers in math) × 2（target salience: salient PM tasks embedded in ongoing tasks, non-salient PM tasks embedded in ongoing tasks） × 2（task importance: emphasizing the importance of PM tasks, no importance emphasized）mixed factorial design was used. Target salience was manipulated as a within subject factor and task importance and achieving group as between subject factors. Additionally, all participants completed a set of baseline tasks which only included ongoing tasks but no PM tasks. The dependent variables were response accuracy and response time of PM and ongoing tasks.

There were 2 blocks in each condition (including 240 trials). Each stimulus was displayed for the maximum of 2500 ms or until a response was made, then followed by a blank, with the SOA (stimulus onset asynchrony) as 3000 ms, and then the letter for the next trial was presented (see Fig. 1). In the baseline (1-back tasks), individuals were asked to judge whether or not the letter currently presented was the same as the previous letter. If it was the same, participants were asked to respond quickly by pressing the F-key and the J-key if it was different. Each PM condition involved the embedded event-based PM tasks and 1-back tasks which were the same as the baseline in procedure. Participants were instructed to do 1-back task continuously and when the PM target (letter D) appeared, they should respond by pressing the K-key as quickly as they can. PM targets occurred three times in each condition. They are in red (different color from 1-back trials) in salient conditions and in black (same color as 1-back trials) in non-salient conditions. The baseline condition and the salient and non-salient condition were counterbalanced across participants. In importance emphasized condition, participants were informed that PM tasks were more important than 1-back tasks. In no emphasis condition, no information about task importance was provided. Both high achieving and low achieving pupils were randomly assigned to important condition and no emphasis condition. The intelligence scores of high achieving pupils in important condition (49.18 ± 4.60) and no emphasis condition (50.29 ± 3.01) were matched ($t(93)=-1.01$, $p>.31$) , and the intelligence scores in low achieving pupils in important condition (46.14 ± 3.64) and no emphasis condition (44.24 ± 4.15) were also matched ($t(93)=1.60$, $p>.12$).

The experiment was compiled by e-prime1.1, Psychology Software Tools and was presented on computer. Each participant completed the experiment separately in the lab. The entire session lasted about 20 minutes before participants completed all of the tasks.

2.2.3 Analysis

SPSS 12.0 (IBM, Chicago, Illinois) was used for all statistical analysis.

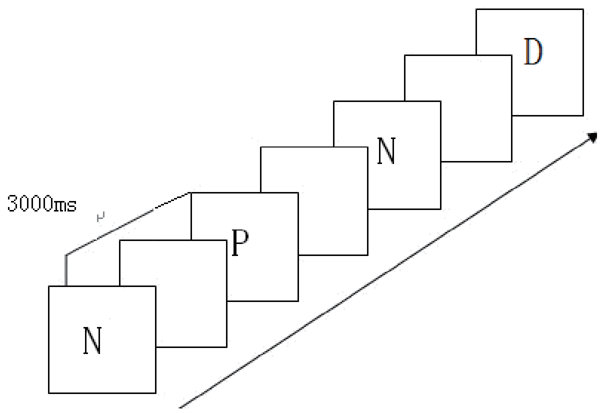

Fig. 1 letter by letter presentation of ongoing 1-back tasks and embedded PM tasks

3 Results

3.1 Performance of PM

Mixed 2 (achieving group) × 2 (target salience) × 2 (task importance) analysis of variance (ANOVA) models were used to evaluate the accuracy and reaction time (showed in table 2) of PM tasks. For the accuracy, the main effects of target salience ($F(1, 91) = 311.01$, $p<.001$, $\eta^2=.77$) and achieving group ($F(1, 91) = 12.94$, $p<.01$, $\eta^2=.12$) were significant. The accuracy of PM was lower for low achieving pupils and non-salient conditions than high achieving pupils and salient conditions. There was no main effect for task importance, $F(1, 91)=2.56$, $p>.11$, but the interaction between task importance and target salience was significant, $F(1, 91)=4.08$, $p<.05$, $\eta^2=.04$. Simple effect showed that when PM target was non-salient, PM accuracy was higher for importance emphasized condition than for no importance emphasized condition ($t=2.26$, $p<.05$), but when PM target was salient, there was no difference in PM accuracy between two different importance levels ($t=.30$, $p>.38$).

For the response time, the main effects of target salience ($F(1, 91)=18.75$, $p<.001$, $\eta^2=.17$) and task importance ($F(1, 91)=11.85$, $p<.01$, $\eta^2=.12$) were significant. The response time of PM was longer for non-salient condition and importance emphasized condition than salient condition and no importance emphasized condition. There were no main effects for achieving group, $F(1, 91)=.46$, $p>.12$ and no interactions, Fs (1, 91) = .01~2.16, $ps>0.15$.

3.2 Prospective interference effect

The goal of this section was to examine whether performing a PM task affected the accuracy and response time of the ongoing tasks.

Mixed 2 (achieving group) × 2 (task importance) × 3 (target salience: salient condition, non-salient condition and one baseline condition) analysis of variance (ANOVA) models were used to evaluate the accuracy and response time of ongoing tasks. For the accuracy (showed in table 4), there was significant main effect for target salience, $F(2, 182)=28.53$, $p<.001$, $\eta^2=.24$. The accuracy of ongoing tasks was lower for the PM conditions than their corresponding baseline ($ps<.001$), and no difference was found between the accuracy of ongoing tasks in salient and non-salient PM conditions ($p>.15$). No other main effects and interactions were observed, $Fs=.32-1.47$, $ps>.23$.

Table 2 Accuracy of PM by task importance and target salience

Target salience	importance emphasized				no emphasis			
	HA (n=28)		LA(n=22)		HA(n=24)		LA(n=21)	
	ACC	RT	ACC	RT	ACC	RT	ACC	RT
non-salient	.60(.29)	823(155)	.39(.24)	821(176)	.45(.18)	713(116)	.32(.22)	782(89)
salient	.94(.11)	753(114)	.82(.13)	758(125)	.90(.12)	653(88)	.85(.30)	714(101)

For the response time (showed in table 3), there was a significant main effect for target salience, F(2, 182)=25.90, p<.001, η^2=.22. The interaction between target salience and importance emphasis was significant, F(2, 182)=5.12, p<.01, η^2=.05. Simple effect showed that when task importance was emphasized, the response time among three tasks was significant, F(2, 182)=31.49, p<.001. The response time was longer for the non-salient PM condition than the baseline (p<.001) and salient PM condition (p<.001), and there was no significant difference between salient PM condition and the baseline (p>.11). When no importance was emphasized, the response time among three tasks was also significant, F(2, 182)=3.53, p<.05. The response time was only marginally longer for the non-salient PM condition than the baseline (p<.06) and salient PM condition (p<.05), and there was no significant difference between salient PM condition and the baseline (p>.73). No other significant main effects and interactions were found, Fs=.98-3.53, ps>.06.

4 Discussion

4.1 PM performance

In the present study, task importance and target salience had interaction effect on PM performance. When PM target was non-salient, PM accuracy was higher for importance emphasized condition than no importance emphasized condition, but when PM target was salient, there was no difference in PM accuracy between two different importance levels. Maybe PM tasks with salient targets were too easy and their accuracy were close to ceiling in the salient PM condition, thus the effect of importance emphasis did not occur. Similarly, the experiment (Einstein et al., 2005) on the effect of task importance and focal vs. non-focal target on PM performance has shown that stressing importance influenced PM accuracy only in the non-focal condition but not in the focal condition. Results from the above two studies suggested that, when PM targets were easy to be identified, the effect of task importance on PM accuracy might not occur. Otherwise, the effect of task importance on PM might occur in PM response latency. The present research showed that stressing task importance slowed down PM latency not only in the salient condition but also in the non-salient condition. Slower PM latency in importance emphasis condition than that in no emphasis condition suggested that stressing importance of PM made all pupils pay more attention to PM tasks, and slowed down their responses. This suggested that all pupils could adjust their processing strategy of PM according to whether the PM tasks were important or unimportant.

Table 3 Accuracy of ongoing tasks by task importance and target salience

target salience	importance emphasized				no emphasis			
	HA (n=28)		LA(n=22)		HA(n=24)		LA(n=21)	
	ACC	RT	ACC	RT	ACC	RT	ACC	RT
non-salient	.89(.08)	771(75)	.85(.08)	780(114)	.87(.08)	672(96)	.87(.07)	758(87)
salient	.86(.06)	710(86)	.85(.06)	715(137)	.86(.06)	657(85)	.87(.07)	703(105)
corresponding baseline	.92(.04)	692(93)	.90(.06)	688(129)	.91(.08)	670(100)	.92(.07)	699(90)

Target salience enhanced PM accuracy and made PM response time faster than that in non-salient condition. Visual saliency made PM target easier to be identified, so the PM accuracy was improved and the response time was lessened. As have demonstrated in previous studies, all age groups benefited from the presentation of salient PM targets except for old adults (Kretschmer-Trendowicz & Altgassen, 2016). In the present study, the PM performance benefits of increased visual saliency were observed in both high and low achieving pupils. It suggested that salient targets could capture attention of all pupils and low achieving pupils had no difficulty in distinguishing salient targets.

Results in the present study also showed that no interaction effect was observed between achieving group and target salience or task importance. It meant that target salience and task importance influenced PM in the two achieving groups in the same way. That is, all participants including low achieving pupils could identify important vs. unimportant tasks and salient vs. non-salient target and made flexible strategy adjustment to PM tasks, but low achieving pupils still performed worse in all PM tasks. This may due to their deficits in executive functions which involved in PM (Mahy, Moses, & Kliegel, 2014; Zeng & Wu, 2004) and their worse transferring competence between PM tasks and ongoing tasks (Ji, 2012). Some studies (Gathercole & Pickering, 2000; Zeng & Wu, 2004) have found that low achieving pupils had some deficits in the executive functions which involved in the encoding, maintenance and retrieval of PM intentions (Mahy & Moses, 2011; Mahy et al., 2014). So low achieving pupils performed worse than high achieving pupils in PM tasks, which was also demonstrated by Ji (2012). Ji's research (2012) showed that PM accuracy was higher and response time was faster for high achieving pupils than low achieving pupils, and high achieving pupils were better at transferring between PM tasks and ongoing tasks. The above researches has provided support for the present study.

4.2 Prospective interference effect

In this present study, the accuracy of ongoing trials was lower for salient and non-salient PM conditions than their corresponding baselines, which means performing both salient and non-salient PM produced task interference on the accuracy of performing the ongoing tasks. It suggested that performing PM tasks in the present study consumed some cognitive resources. The results confirmed PAM theory (Smith, 2003; Smith & Bayen, 2004), which proposed that capacity-consuming preparatory processes must be engaged for successful event-based PM and task interference effect always existed when possessing a PM intention. The results were consistent with some studies which suggested that PM tasks with both salient and non-salient target have interference on ongoing activities (Smith, Hunt, McVay, & McConnell, 2007). In Smith's study, they used salient PM target cues in four experiments, two of which were designed to meet the stringent criteria proposed for automatic retrieval of intentions by multiprocess view. In all four experiments, Smith et al. found that delayed intentions interfered with the ongoing task performance. These studies demonstrated PAM theory and were inconsistent with the multiprocess view, which predicted that no task interference resulting from PM would occur when the cue was salient.

Results from present study showed that non-salient targets produced greater cost to the ongoing activity than did salient targets. Previous researches also showed that the task interference from non-salient PM target was greater than salient PM target (Chen et al., 2009). Since it was difficult for participants to identify non-salient PM targets, and the PM tasks would occupy participants more cognitive resources in non-salient target condition. So the accuracy and response time of ongoing tasks would be more interfered by non-salient PM tasks.

Results also showed that instruction with importance emphasis only had impact on the response time of ongoing tasks in the non-salient condition. The reason might be that salient targets in the PM tasks were easy to be identified and the ongoing tasks were so easy in this present study, so subjects had enough cognitive resources to complete the total tasks. Even if participants allocated more resources on the PM tasks in importance emphasis condition, they still had enough resources to perform the ongoing tasks, thus the ongoing tasks were not interfered. Otherwise, when PM targets were non-salient, PM tasks required more resources and participants had no enough resources to complete the total task, thus the task importance emphasis had impact on the response time of the ongoing tasks only in the non-salient condition. And interference effect was greater for the importance emphasis condition than no emphasis condition, since pupils allocated more cognitive resources on PM when the task importance was emphasized. Similarly, Einstein et al. (2005) has explored the impact of importance and focal vs. non-focal PM target on prospective interference, the results showed that stressing importance influenced responses time of ongoing tasks only in the non-focal condition. And interference effects were greater for the importance emphasis condition than no emphasis condition. These results suggested that individuals allocated cognitive resources according to characteristics of tasks, even low achieving pupils in math could flexibly allocated their cognitive resources. They allocated more resources to more important and more difficult tasks, thus more interference produced to the responding ongoing tasks.

4.3 Practical applications

This study has enriched the knowledge of PM characteristics in pupils. According to this study, emphasizing task importance didn' t improve PM accuracy but increased PM reaction time when PM tasks are with salient target, so it is unnecessary to emphasize PM with salient target. But when PM target is not salient, it is useful to stress the importance of PM tasks, for stressing improves PM performance. Setting up a salient target for PM tasks benefits PM performance. So it is very important to help pupils learn to set up a salient target for their PM tasks. Teachers and adults should help pupils, especially low achievers to learn to set up salient PM targets in their daily life. And if PM tasks are with non-salient target, low achieving pupils should learn to stress task importance to improve the performance. Once low achieving pupils do not forget what teachers tell them to do, their academic achievement would be improved.

5 Conclusions

High achieving pupils outperformed low achieving pupils in PM tasks. Salient targets improved PM performance for all pupils. Emphasizing task importance improved PM accuracy when PM target was non-salient, but produced more interference to the ongoing tasks. Both high and low achieving pupils in math could flexibly allocated their cognitive resources according to the characteristics of tasks. The better strategy to improve PM performance is to establish a salient target for one's PM tasks. If the target can't be salient, then emphasizing the importance of the PM tasks.

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目标显著性和任务重要性对数学学业不良生和学优生前瞻记忆和前瞻干扰效应的影响

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摘　要　有问卷调查表明，个体的学业成绩特别是数学成绩与前瞻记忆表现有一定的相关，学业不良生报告更多的前瞻记忆失败。也有实验研究显示，学业不良生在很多情况下前瞻记忆表现劣于学优生。但是，影响学业不良生前瞻记忆表现的因素却并不是很明确。本研究从目标显著性和任务重要性这两个可以着手于改善前瞻记忆的主要因素入手，考察其对数学学业不良生和学优生事件性前瞻记忆和前瞻干扰效应的影响，以期为提高学业不良生的前瞻记忆表现提供实证依据。

采用 2 学业成就（学业不良生、学优生）×2 前瞻记忆任务重要性（强调重要、不强调）×2 目标显著性（显著、不显著）混合实验设计，目标显著性为被试内变量，其他两个因素为被试间变量，在双任务实验范式（前瞻记忆任务镶嵌于进行中任务）中，考察三个因素对前瞻记忆正确率和反应时的影响。此外，被试还需完成基线条件，在基线条件下被试只有进行中任务，没有前瞻记忆任务，通过实验条件和基线条件的正确率和反应时差异，考察前瞻记忆任务对进行中任务的干扰效应，推测前瞻记忆的加工机制。结果表明，学业不良生所有前瞻记忆任务表现均劣于学优生；目标显著性与前瞻记忆任务重要性对前瞻记忆正确率有显著的交互作用，强调任务重要性使目标不显著条件下的前瞻记忆正确率提高，对显著条件的前瞻记忆正确率没有影响。强调任务重要性使所有实验条件的前瞻记忆反应时下降，目标显著使所有实验条件的前瞻记忆正确率提高。所有实验条件进行中任务正确率低于基线条件，反应时也慢于基线条件，表明执行前瞻记忆任务对进行中任务产生了干扰，学业不良生和学优生在本实验条件下对前瞻记忆任务均采用监控的加工方式。结果说明，学业不良生前瞻记忆成绩较差，可以通过设置显著的目标提高其前瞻记忆成绩，当目标显著时无需强调其重要性，若无法设置显著的目标，则通过强调任务重要性提高前瞻记忆表现。

关键词　事件性前瞻记忆 学优生 学业不良生 目标显著性 任务重要性 前瞻干扰效应