Cognition, Brain, Behavior. An Interdisciplinary Journal, 2017
Volume XXI, No. 1 (March), 1-12, ISSN: 1224-8398

Semantic Processing as a Significant Factor in Non-Focal Prospective Memory Cues

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Abstract

The aim of the current study was to explore the impact of cue focality and semantic task-appropriate processing on prospective memory (PM) performance and whether this potential effect would be moderated by differences in ongoing task demands. A 3 X 2 mixed factorial design was used where cue focality (focal, semantic non-focal, nonsemantic non-focal) was manipulated within-participants, and ongoing task demands (high, low demands) were manipulated between participants. A significant effect of focality was identified, where semantic nonfocal cues have produced the lowest level of PM performance. Nevertheless, this effect was not moderated by ongoing task demands, which have also not affected PM performance independently. PM results are discussed in the light of the multiprocess framework, arguing that semantic non-focal cues might have been perceived by the participants as less demanding, hence failing to engage controlled monitoring processes, which might have supported PM performance in such contexts.

Keywords: Prospective Memory; Cue Focality; Ongoing Task Demands; Semantic Processing

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Prospective memory (PM) is a cognitive construct described as the ability to perform an intended action at the appropriate moment or in the appropriate context (McDaniel & Einstein, 2007). Event-based PM involves remembering to perform an intended action when cued by the environment - for example, remembering to purchase milk (intended action) when passing a supermarket (PM cue). PM failures are ubiquitous in everyday life, such as forgetting to give a message to a friend, or forgetting to charge your phone when you see its low battery sign. It is therefore of little surprise that PM is predicted to account for at least half of everyday memory failures (Kliegel & Martin, 2003).

One of the leading theories of PM is preparatory attention and memory processes (PAM) theory (Smith, 2003). This theory suggests that PAM processes are engaged during PM tasks, which often leads to errors in other ongoing activities (Smith, Hunt, McVay, & McConnell, 2007). If PAM processes would not be engaged, then the PM cue would not be recognised. Alternatively, the multi-process framework (McDaniel & Einstein, 2000) suggests two pathways for prospective remembering – via either conscious effort or via spontaneous retrieval (McDaniel & Einstein, 2000; McDaniel, Robinson-Riegler, & Einstein, 1998). Spontaneous retrieval is an automatic process, defined by the PM retrieval occurring without conscious thought, and without it interfering with another task (Posner & Snyder, 1975).

It is well established that the more cognitively demanding an ongoing task is, fewer resources will be available for the PM task (Kvavilashvili, 1987; Marsh, Hancock & Hicks, 2002), likely resulting in PM failure. Smith (2003) found that there were more ongoing task errors and PM failures when capacity demands were increased, indicating that the PAM processes required for an ongoing task are siphoned from monitoring resources. Using the conditions that multi-process framework suggests should lead to no such costs on performance, Smith et al. (2007) found such costs, the authors arguing that preparatory processes are engaged whether they are necessary or not. Scullin, McDaniel, and Shelton (2013) provide evidence that monitoring occurs when the cue is expected, and is disengaged when a cue is not expected. Accordingly, when disengaged, spontaneous retrieval can support prospective remembering. This denotes that monitoring and spontaneous retrieval are dynamically interconnected as the engagement of either process is dictated by the expectation of a PM cue. Although this can support the multi-process theory, it is important to note that PAM can include processes far more subtle than the monitoring processes measured in this experiment (Smith, 2010).

A PM cue can be defined as when information relevant to the ongoing task overlaps with encoded PM cue features (Einstein & McDaniel, 2005; Gordon, Shelton, Bugg, McDaniel & Head, 2013). When there is a large overlap between the information relevant for the ongoing task and for the target event, the PM cue is considered focal. If the information required for the target event requires different processing than the ongoing activity, then it is considered a non-focal PM cue (Einstein et al., 2005). Similar to this is the proposition of task-appropriate processing, such as semantic encoding-semantic retrieval. Studies show that task-appropriate processing results in significantly better PM performance compared to cases where the task requires inappropriate processing (Marsh, Cook, & Hicks, 2005; Meiser & Schult, 2008). In the current study, we propose that the effects of cue focality can be altered by whether or not task-appropriate processing is employed.

Research consistently finds that focal cues are recognised by spontaneous retrieval alone, whereas non-focal cues require controlled monitoring for PM success (Einstein et al., 2005; McDaniel et al., 2013). This finding is exacerbated when cognitive resources are strained in non-focal conditions by the introduction of a dual task (Smith, 2003), supporting the notion that non-focal cues require monitoring. In support to the assumption that focal cues do not require monitoring resources, some studies have shown that they can be detected without an expense to the ongoing task (Harrison & Einstein, 2010), and independent of whether the cognitive demands are low or high (Meiser & Schult, 2008). There is also a growing body of evidence that suggests that focal cues are temporarily immune to forgetting - when participants are informed that the PM task has ended, they continue to react to the PM cue (Scullin & Bugg, 2013).

When self-initiated demand is put on both tasks there is no significant increase in PM performance for focal or non-focal cues, thereby suggesting that attentional demands moderate cue focality.

The present study

The aim of the current study is to examine the impact of varying levels of focality on PM performance, and whether the potential effect is moderated by ongoing task demands. As the ongoing task involved semantic processing, the following types of PM cues were used: (1) focal, (2) semantic non-focal (Snon-focal), and (3) non-semantic non-focal (NSnon-focal).

The focal PM cue was the word 'sparrow', the Snon-focal PM cue was a word designating a bird, whereas the NSnon-focal PM cues was any eight-letter word. The ongoing activity consisted in sorting words into 'natural' or 'manmade' categories per their meaning. We assumed that the NSnon-focal PM cue is indeed NSnon-focal as the ongoing task requires category judgement of unitized lexical items, which does not emphasise an awareness of word-length. To detach this from saliency effects all words have been capped to four to ten characters.

In regards to the Snon-focal condition, semantic-semantic processing was induced such that word stimuli would require meaning processing of the words in order to judge if some of them pertain to the bird category, and the same processing type is required by the ongoing task. However, a specific word stimulus was not provided, minimising the overlap between encoding and retrieval, making it distinctly different to the focal PM cue retrieval.

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The current research aimed to investigate the impact of cue focality and semantic task-appropriate processing on PM performance and whether this potential effect would be moderated by differences in ongoing task demands. First, we hypothesized that PM performance would increase as the level of cue focality increases from NSnon-focal, through Snon-focal, to focal cues. Second, it was anticipated that participants in the ongoing low demand condition would perform significantly better on the PM task than those in the high-demand condition, irrespective of focality. Finally, we also predicted an interaction between the main factors of interest whereby the focality effect on PM performance would be moderated by ongoing task demands, with high ongoing task demands affecting PM performance to a greater extent as the level of focality decreases. This investigation of Snon-focal cues, alongside the typically studied focal and NSnon-focal cues, has the potential to add to our understanding of how cues are perceived, and how this affects the selection of a specific cognitive pathway (spontaneous retrieval or controlled monitoring).

METHOD

Participants

Fifty-three healthy adults (38 females and 15 males) volunteered to participate in this study. The mean age of participants was 24.52 (*SD* = 8.86). Partial course credit was awarded for participation. Table 1 reveals the characterization of our sample regarding age as well as means and standard deviations for participants' performance on the main tasks, as a function of ongoing task demands (high vs low).

Table 1
Means (and standard deviations) for participants' age, PM accuracy as a function of focality conditions, Ongoing task errors and Ongoing task reaction times in the low and high demanding ongoing conditions.

		Low demand	High demand
N		27	23 [a]
Age (years)		23.96 (6.06)	25.17 (11.43)
PM accuracy	Focality conditions	5.67 (0.62)	5.83 (0.39)
	Semantic non-focal	3.93 (1.59)	3.43 (1.83)
	Non-semantic non-focal	4.37 (1.57)	4.30 (1.55)
Ongoing task errors		12.20 (1.40)	12.64 (1.52)
Ongoing task reaction times		1433.81 (90.20)	1596.23 (97.73)

[a] Three participants were removed from the data set by the researcher due to non-compliance with the instructions of the task, all of whom were in the high demand condition.

Ongoing task

The ongoing task was a computer-based psycholinguistics task built on SuperLab 4.5 software. The premise of this task was to decide as quickly as possible whether the word presented was 'natural' or 'manmade'. The words were gathered from the MRC psycholinguistics database (Coltheart, 1981). 'Familiarity' and 'Concreteness' ratings were restricted to 200-600 to avoid particularly salient words and all word options other than 'noun' were excluded from the common part of speech and comprehensive syntactic categories. The length of the words was capped between four and ten letters. Words that constituted as 'natural' or 'manmade' were extracted from the word output provided. All words were randomised before being inputted into SuperLab 4.5. The words were the same between the low and high demand conditions, but differed between focality conditions to avoid learning effects. Natural words included 'elephant', 'river', and 'raspberry', and manmade words included 'hairpin', 'drill', and 'flag'. Participants were instructed to press the 'z' key for natural words, and the '/' key for manmade words, and to respond both as quickly and as accurately as possible. There were 160 words presented in each task. This task remained identical for participants in both the low and high demand conditions, besides that participants in the high demand condition were asked what the last three words were at certain intervals, at which point they had to verbally tell the researcher. This was purely to add a concurrent demand and correct answers for this were not recorded.

PM task

The PM task was embedded into the ongoing task, such that participants were instructed to press a separate key when the PM cue appeared. The PM cues differed as a function of their focality, hence there were three focality conditions: the (1) focal PM cue condition, (2) Snon-focal PM cue condition, and (3) the NSnon-focal PM cue condition. The focal PM cue was the word "sparrow", the Snon-focal PM cue was 'a word which designating a bird', and the NSnon-focal PM cue was 'an eight-letter word'. The PM task was to press the 'p' key when the PM cue appeared. Six PM cues appeared in each ongoing task (low and high demand).

Procedure

An application for Ethical Approval was submitted to the Research Ethics Committee of the University of Chichester. The experiment proceeded only after ethical approval was granted. All data collected was kept completely confidential, used for statistical analysis and stored and disposed of according to the Data Protection Act and Quality Assurance procedures of the University.

Participants were placed into the experimental conditions by sequential random allocation to ensure an equal number of participants in the ongoing task demand conditions, and eliminate order effects in the focality conditions. Each participant took part in either the low demand condition or the high demand condition, and took part in every focality condition.

All participants were first given instructions for the ongoing task and permitted one practice, consisting of twenty words. The participants were then shown the instructions for the first computer task. They were given a demographic questionnaire to complete which acted as a delay before starting the first task. This process was repeated for each of the three tasks, with the Trail Making Test (Army individual test battery, 1944), and the Cognitive reflection test (Frederick, 2005) acting as the delay tasks. These were also able to provide some information in regards to the participants abilities in shifting and updating.

Results

PM performance

A 3 X 2 ANOVA was conducted to explore the effects of cue focality (focal, Snon-focal, NSnon-focal) and ongoing task demands (high, low) on PM performance. In each task the maximum PM score was six as there were six PM cues.

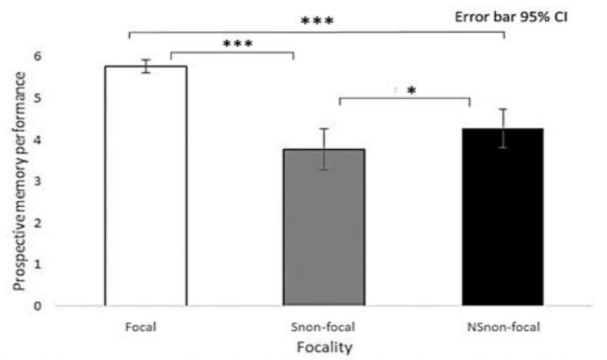

Figure 1. Mean correct responses to PM cues across all focality conditions. *** denotes significance at the .001 level (2-tailed); * denotes significance at the .05 level (2-tailed).

A significant main effect was identified for cue focality, $F(2, 96) = 39.14$, $p < .001$, $\eta p^2 = .45$. Furthermore, the main effect of ongoing task demands failed to reach significance, $F(1, 48) = .23$, $MSE = .22$, $p = .63$, $\eta p^2 = .01$. Finally, there was no significant interaction between cue focality and ongoing task demands, $F(2,96) = .96$, $MSE = 1.36$, $p = .39$, $\eta p^2 = .02$.

PM performance was therefore similar between the low demand ($M = 5.67$, $SD = 0.62$) and high demand conditions ($M = 5.83$, $SD = 0.39$, $p > .05$) in the focal condition. The same pattern can be observed in the NSnon-focal condition where the PM score in the low demand ongoing activity task ($M = 4.37$, $SD = 1.57$) was similar to that in the high demand condition ($M = 4.30$, $SD = 1.55$, $p > .05$). Finally, the same pattern was identifiable again in the Snon-focal condition, where the low demand condition ($M = 3.93$, $SD = 1.59$) produced a similar PM performance to that in the high attentional demand condition (*M* = 3.43, *SD* = 1.83, $p > .05$).

When exploring the focality results independently from ongoing task demands, there are significant differences between all conditions. Post-hoc analysis revealed that PM performance was best in the focal condition (*M* = 5.75, *SD* = .08) and significantly better than the Snon-focal condition (*M* = 3.68, *SD* = .24, 95% CI [1.48 to 2.65], $p < .001$). Performance in the focal condition was also better than the NSnon-focal condition (*M* = 4.34, *SD* = .22, 95% CI [.83 to 1.99], $p < .001$). Importantly, PM performance in the NSnon-focal condition (*M* = 4.34, *SD* = .22) was significantly better than performance in the Snon-focal condition (*M* = 3.68, *SD* = .24, 95% CI [.05 to 1.27], $p < .03$). These results are displayed in Figure 1.

The ongoing task demands condition shows no significant difference between groups. Findings show that PM performance was not significantly better in the low demand ongoing task (*M*= 4.65, *SD*= .19) compared to that in the high demand task (*M* = 4.52, *SD* = .22, $F(1, 48) = .23$, $p = .63$, *MSE* = .22, $\eta p^2 = .01$.

Ongoing task errors

Ongoing task errors were analyzed with a 3 X 2 mixed factorial ANOVA, with the within groups factor cue focality (focal, Snon-focal, NSnon-focal) and the between-groups factor ongoing task attentional demands (high, low). There was a main effect of cue focality, $F(2, 96) = 9.49$, $p <.001$, $\eta_p^2 = .17$. Post-hoc tests reveal that there were significantly more errors made in the NSnon-focal condition (*M* = 14.80, *SD* = 1.24) than in the focal condition (*M* = 11.16, *SD* = 1.07, 95% CI [1.06 to 6.21], $p = .01$) or the Snon-focal condition (*M* =11.29, *SD* = 1.19, 95% CI [1.28 to 5.74], $p = .01$). However, there was no significant difference in errors between the focal (*M* = 11.16, *SD* = 1.07) and Snon-focal conditions (*M* =11.29, *SD* = 1.19, 95% CI [-2.36 to 2.10], $p = 1.00$).

There was no significant effect of ongoing task demands on errors made in the ongoing task ($F(1,48) = .05$, *MSE* = 2.41, $p = .83$, ηp^2= 01. Descriptive analyses reveal very slight difference between the low demand condition (*M* = 12.20, *SD* = 1.40) and the high demand condition (*M* = 12.64, *SD* = 1.52). There was also no interaction effect between focality and ongoing task demands on the number of errors made on the ongoing task ($F(2, 96) = 1.18$, *MSE* = 26.36, $p = .31$, $\eta p^2 = .02$).

Reaction times

Reaction times for the ongoing task were investigated as a potential indicator of the effects of cognitive load. Reaction times were measured in milliseconds, measuring the time between the presentation of the word stimulus and participant's response by pressing a key on the keyboard. There was a significant effect of cue focality on reaction times ($F(2, 96) = 53.93$, $p < .001$, $\eta p^2 = .53$). Post-hoc tests identify the average reaction time for the NSnon-focal condition (*M* = 1764, *SD* = 80.28) as significantly slower than both the focal condition (*M* = 1397, *SD* = 64.35, 95% CI [276 to 535], $p < .01$) and the Snon-focal condition (*M* = 1422, *SD* = 66.68, 95% CI [234 to 447], $p < .01$). However, there was only a marginal significant difference between the focal condition (*M* = 1397, *SD* = 64.35), and the Snon-focal condition (*M* = 1422, *SD* = 66.68, 95% CI [-132.74 to 2.73], $p = .06$).

There was no significant effect of ongoing task demands on reaction times ($F(1,48) = 1.49$, $p = .23$, $\eta p^2 = .03$). Descriptive analyses show that average reaction times to the stimuli on the ongoing task in the low demand condition (*M* = 1433.81, *SD* = 90.20) were slightly faster than those in the high demand condition (*M* = 1596.23, *SD* = 97.73), but to no significance. There was also significant interaction of focality and ongoing task demands regarding reaction times ($F(2, 96) = 3.07$), $p = .05$, $\eta p^2 = .06$).

Discussion

Across this study a significant effect of cue focality has been identified in PM performance. Specifically, in terms of their PM performance, participants were most successful in the focal condition and least successful in the Snon-focal condition. Hence, despite typically requiring more cognitive resources, the NSnon-focal condition yielded a better performance than the Snon-focal one.

Regarding the influence of ongoing task demands on PM performance, there was neither a significant main effect nor a significant interaction between low and high ongoing task demands across the varying degrees of focality. Thus, it might be that the high ongoing task demands were not demanding enough to elicit more PM failures compared to the low demanding condition. With these results, we cannot conclude that there is no interactive effect between cue focality and ongoing task demands upon PM performance. Future research could ensure that the two ongoing conditions exert different impacts upon PM performance before testing for cue focality*ongoing demands interactions.

Error rates on the ongoing task reveal that focal and Snon-focal conditions had fewer errors, whereas the NSnon-focal condition had significantly more. Similarly, for reaction times, the focal and Snon-focal conditions had moderate reaction times whereas the NSnon-focal condition had significantly longer reaction times.

It was anticipated that PM performance in focal, Snon-focal, and NSnon-focal conditions would increase in consonance with the increments in focality. Although there was a significant effect of focality identified, the trend observable did not present the expected pattern. Interestingly, the results from this study revealed that participants' PM performance was at its best in the focal condition, and at its worst in the Snon-focal condition. Although at odds with our hypothesis, this finding can be explained in the light of the multi-process framework. Accordingly, when the PM retrieval conditions are perceived as being less demanding spontaneous retrieval is more likely relied upon, and when these are perceived as more demanding controlled monitoring is activated (Einstein et al., 2005). This is consistent with the pattern observed in the current findings as there was also an increase in errors on words containing seven and nine letters, where participants presumed they were eight-letter words and pressed the PM key. This indicates a hyper-awareness for long words, suggestive that participants adopted monitoring in this condition. There was an increase in reaction times in the NSnon-focal condition only, indicating that more cognitive resources were engaged (Einstein et al., 2005; Harrison & Einstein, 2010). Errors in the ongoing task and reaction times were relatively lower for the focal and Snon-focal conditions compared to the NSnon-focal condition, which would suggest that monitoring was not deployed in either the focal or the Snon-focal conditions (Posner & Snyder, 1975). It could therefore be implied that participants did not perceive the Snon-focal cue to be so demanding as to engage in monitoring, but the cue was in fact abstract enough to not be detected by spontaneous retrieval alone. The Snon-focal cue may be perceived this way as it still requires semantic processing. This supports McDaniel and Einstein's (2007) theory that the anticipation of the absence of a good cue results in the participation of monitoring.

The mean RT for the focal condition was marginally faster than the Snon-focal condition, however PM cue detection in the focal condition was significantly more accurate than in its Snon-focal counterpart. This suggests that the anticipation of focal and Snon-focal cues lead participants to disengage in processes of monitoring for the PM cue, however this did not suffice in the Snon-focal condition. The mean RT times for the NSnon-focal condition are significantly slower than both other focality conditions, suggesting monitoring was engaged, which resulted in comparatively medium PM success. Looking closer at the data it is evident that when RT's increased in the Snon-focal and NSnon-focal conditions PM retrieval improved. However, this pattern is not seen in the focal condition, suggesting that time-exhaustive monitoring is unprofitable for focal cues.

It was hypothesised that the low demand condition would foment a significantly better PM performance than the high demand condition and, additionally, an interaction effect would be identifiable whereby focality would be moderated by the level of ongoing task demands, as indicated by Meiser and Schult (2008). Their hypothesis was not supported by the results of the current study, despite it being consistently found throughout the literature (see Marsh et al., 2002). Working memory has previously been a successful manipulation of ongoing task demands (West & Bowry, 2004), but there has been literature suggesting engagement of the phonological loop does not affect PM (Marsh et al., 2002). When participants anticipate that they will need to recall words, they will usually attempt a continuous rehearsal technique to aid retrieval. It is therefore reasonable to deduct that the phonological loop was the primary mechanism being employed in the high demand condition, which can explain the lack of a significant difference between the two conditions. This was the most noteworthy limitation of this research, as the failure to secure a significant effect in the ongoing task demands condition, due to an ineffective method, entailed that we could not then conclude that there was no interactive effect upon PM performance.

Most importantly, we anticipated that ongoing task demands would impair PM performance to a greater extent as the level of focality decreased. The present study failed to support this. As the results from the focality condition reveal that the worst PM performance was in the Snon-focal condition. This hypothesis might inform and contextualize future replications as to predict that ongoing task demands might dictate performance to a greater extent as focality moves from focal, to NSnon-focal, to Snon-focal. The current study highlights preliminary findings that seem to imply that Snon-focal cues are independent from focal and NSnon-focal cues. It would be of significant value to undertake qualitative research that addresses participants' intentions as to which PM pathway they think appropriate, in regards to a variety of tasks where focality, and task demands are manipulated.

Conclusions

The results of the current study reveal significant differences in PM performance between focal, NSnon-focal, and Snon-focal conditions, with the Snon-focal condition yielding the lowest level of performance. This can be explained in the light of the multi-process framework in that for Snon-focal cues monitoring might not be implemented as the cue might not be perceived to require monitoring. Nevertheless, the cue might indeed be too abstract to be detected by spontaneous retrieval. This highlights the importance of an individual's perception of the focality of the PM cue.

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