Is prospective memory enhanced by cue-action semantic relatedness and enactment at encoding?

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Abstract

Benefits and costs on prospective memory performance, of enactment at encoding and a semantic association between a cue-action word pair, were investigated in two experiments. Findings revealed superior performance for both younger and older adults following enactment, in contrast to verbal encoding, and when cue-action semantic relatedness was high. Although younger adults outperformed older adults, age did not moderate benefits of cue-action relatedness or enactment. Findings from a second experiment revealed that the inclusion of an instruction to perform a prospective memory task led to increments in response latency to items from the ongoing activity in which that task was embedded, relative to latencies when the ongoing task only was performed. However, this task interference 'cost' did not differ as a function of either cue-action relatedness or enactment. We argue that the high number of cue-action pairs employed here influenced meta-cognitive processes, in particular attention allocation, in all experimental conditions.

Many of us have experienced the embarrassment of forgetting to turn off our mobile phone before attending a concert or a work meeting. Although we intended to do so, our intention 'slipped our minds', even if only for a few crucial moments. Such failures to recall an intention to do something at a future moment, described as errors of prospective remembering, are not uncommon in everyday life (Ellis & Freeman, 2008; Terry, 1988). Here we investigate the influence of two simple strategies that might be expected to support successful prospective memory performance and explore the demands that their employment places on the recruitment of strategic processes.

A number of different variables have been posited to influence the likelihood that an intention will be retrieved at the correct moment. It has been suggested, for example, that the level of association or integration between a retrieval cue and its intended action is a key factor in determining the likelihood of successfully completing a prospective memory (PM) task (Ellis, 1996; McDaniel, Guynn, Einstein and Breneisser (2004; see also, McDaniel & Einstein, 2000). Consistent with this proposal, McDaniel et al (2004) reported superior PM performance when participants were required to write the word *sauce* upon encountering the cue word *spaghetti* in an ongoing word-rating task, compared to when they had to write *church* upon seeing *spaghetti* (see also Marsh et al., 2003). Moreover, it has been observed that PM responses to cue words from semantically related cue-action pairs are faster than those to cue words from unrelated pairs (Maylor, Smith, della Sala & Logie, 2002). These findings indicate that not only are actions more likely to be retrieved upon the presentation of a related cue than an unrelated one, but also that retrieval may occur more readily under such conditions. Consistent with these findings, McDaniel et al (2004) have observed that PM performance when cue-action pairs are semantically related occurs relatively automatically. It should be noted, however, that Loft and Yeo (2007) failed to observe any influence of cue-action association on PM performance.

One variable that has received relatively little attention from PM researchers is the potential benefits of cue-target enactment at encoding. In the retrospective memory (RM) literature it has long been recognised that the physical enactment of noun-verb phrases (e.g. lift the pen) at study leads to higher recall and recognition performance compared to verbal encoding through reading or listening to these phrases. This has been described as the subject-performed task (SPT) or enactment effect (see Cohen, 1989, for a review). One explanation of the enactment effect is that the performance of an action-object pairing (e.g. lift the pen) during encoding enhances the episodic integration of the two elements (lift and pen) and increases the likelihood that subsequent presentation of the object word as a cue will elicit recall of the associated action (Kormi-Nouri, 1995; see also Engelkamp, 1995). If enactment does indeed enhance object-action integration then it might be expected to mimic the benefits of a high cue-action semantic association and support superior event-based PM performance when the cue is the object for the intended action. Moreover, as with semantic association, it may facilitate greater reliance on automatic, reflexive retrieval.

The beneficial effects of enactment for RM recall may depend on the degree of semantic relatedness between the object and the action in the noun-verb pair. Kormi-Nouri (1995), for example, observed that the effect of enactment on free recall performance was greater when the word pairs were strongly associated than when this conceptual relationship was relatively weak. For cued recall, on the other hand, enactment was significantly more beneficial for semantically unrelated word-pairs than for related ones. Other researchers, however, have reported a conflicting pattern of results. Mangels and Heinberg (2006), for example, observed that the enactment effect on free-recall was greater for semantically unrelated object-action pairs than for related ones, while Engelkamp and Jahn (2003) reported independent effects of enactment at encoding and semantic relatedness in both free and cued-recall tasks. Feyereisen (2009) also observed independent effects in both recognition and cued recall tests.

Although these conflicting findings have yet to be reconciled within the retrospective memory literature, they do raise the possibility that any influence of enactment during encoding on prospective memory performance may be moderated by the level of semantic relatedness between the cue/object and the action. Given some apparent similarities between cued-recall and event-based PM (e.g., the need to retrieve an associated response upon the presentation of a specific cue), Kormi-Nouri's findings suggest that enactment effects will be greater for unrelated than for related cue-action pairs.

The aim of the studies reported here was to explore the benefits of enactment over verbal encoding along with those pertaining to the degree of semantic relatedness of prospective memory cue-action pairings. We report the findings from two experiments that were designed to investigate the influence of these variables on the prospective memory performance of younger and older adults (Experiment 1) and explore the degree to which they modulate the need for strategic resources at retrieval for successful prospective remembering (Experiment 2).

Although older adults frequently express concerns about their performance of intended actions in everyday contexts (cf. Kliegel & Martin, 2003), several studies have reported that they outperform their younger counterparts on naturalistic intentions (e.g., Devolder, Brigham & Pressley, 1990; Rendell & Thompson, 1993). In contrast, in laboratory studies older adults typically display an age-related decrement (e.g., d'Ydwalle, Lewen & Brunfaut, 1999; Maylor, 1993, 1996; Vogels, Dekker, Brouwer &

de Jong, 2002), although the absence of an age-related decrement on an event-based prospective memory task has been reported (e.g., Einstein & McDaniel, 1990; Einstein et al, 1995). One possible reason for these discrepant findings in laboratory settings may lie in the common observation of age-related decrements in attentional resources (e.g., Salthouse, 1991). According to the influential multiprocess framework, developed by McDaniel and Einstein (2000; 2008), several factors are thought to increase the demand on strategic resources for intention retrieval and thus result in an age-related decrement in performance. These include being engaged on a demanding ongoing activity and an underspecified or non-focal cue as well as, importantly in the current context, the strength of the semantic association between a cue and its related action.

A considerable body of evidence has revealed age-related deficits in memory for associations between stimuli, relative to that for the individual items, across a wide range of stimuli that include word pairs (e.g., Castel & Craik, 2003; Naveh-Benjamin, Guez & Shulman, 2004) and word-nonword pairs (Naveh-Benjamin, 2000). One influential account, that is consistent with predictions from McDaniel and Einstein's multiprocess model, proposes that this deficit is a consequence of age-related decrements in attentional resources (e.g., Craik, 1983; Rabinowitz, Craik & Ackerman, 1982). Numerous studies have provided support for this proposal using the contrast between performance under divided and full attention in younger adults (e.g., Kilb & Naveh-Benjamin, 2007; Naveh-Benjamin, Guez, Kiln & Reedy, 2004). Other studies, however, have failed to observe an age-related effect of attentional demands on associative compared with item information recognition memory (e.g., Naveh-Benjamin, Guez & Marom, 2003). Alternative accounts propose that age-related decrements in associative but not individual item memory are a consequence of older adults' difficulty in binding individual items, as described by the associative (Naveh-

Benjamin, 2000) and source monitoring deficit hypotheses (e.g., Chalfonte & Johnson, 1996). In summary, a considerable body of research in retrospective memory suggests that older adults' prospective memory performance may derive greater benefit than younger adults from a stronger cue-action association. It remains unclear, however, whether this benefit arises from a decreased reliance on attentional resources for successful prospective remembering. We consider this question in Experiment 1 and address it in greater depth in Experiment 2.

Early failures to observe an age-related decrement in free recall (retrospective) performance after enactment (e.g., Bäckman & Nilsson, 1985) led some researchers to suggest that the benefits of SPT encoding occurred with no or minimal reliance on strategic resources (e.g. Zimmer, Helstrup & Engelkamp, 2000). Other studies, however, have demonstrated that divided attention can impair performance on both free and cued recall tests when enactment is used at encoding. Although Bäckman and colleagues argue that this indicates some involvement of strategic processes in SPT encoding, it should be noted that the detrimental effect of including a divided attention manipulation is significantly smaller when enactment is used at encoding than in contexts where only verbal information can be encoded (Bäckman & Nilsson, 1991; Bäckman, Nilsson, & Chalom, 1986). Therefore, we might expect to observe greater age-related decrements in prospective remembering after verbal encoding than following enactment of the intentional content.

There is good reason to believe that manipulations of available attentional resources (full vs. divided attention) or contrasts between the performance of younger and older adults may not always provide a sufficiently sensitive indicator of any reliance on strategic resources for successful prospective remembering. Following a seminal article by Smith (2003; see also Smith & Bayen, 2004), prospective memory researchers have investigated the extent to which strategic resources are required for successful prospective memory performance by examining the impact or 'cost' of different manipulations of PM task characteristics on performance of the ongoing task in which the prospective memory target cues are embedded. More specifically, this methodology allows one to examine the attentional costs, on ongoing task accuracy and/or latency, of 'monitoring' events in that task in order to identify a prospective memory target event [1]. This approach is adopted in Experiment 2 to explore the demand for strategic processes to support prospective memory performance following either enactment or verbal encoding with related and unrelated cue-action word pairs.

In Experiments 1 and 2 we employed a relatively challenging, with respect to the potential demands for strategic resources, prospective memory task in which participants were asked to encode six different cue-action (noun-verb) word pairs. The task was to say aloud the relevant action word whenever a cue appeared in an ongoing task in which they were required to categorise each of a series of words as belonging to either the man-made or natural category. In both Experiments 1 and 2 cue-action encoding (enactment, verbal) and semantic relatedness (related, unrelated) were manipulated. Additionally, in Experiment 1 we investigated the relative benefits of these manipulations for younger and older adults' PM performance while in Experiment 2 we explored the costs of these manipulations with respect to performance on the ongoing task in the presence and absence of a PM task.

Experiment 1

In this experiment we focused on investigating the potential benefits of enactment over verbal encoding of prospective memory cue-action pairs and higher compared with

[1] Hicks, Marsh & Cook (2005) describe the additional costs of incorporating a prospective memory task on an ongoing activity as an 'interference effect'.

lower cue-action relatedness on prospective memory performance in younger and older adults. On the basis of findings from retrospective memory research we expected to observe greater age-related decrements in performance when prospective memory cue-action pairs had a lower level of relatedness and were verbally encoded.

Method

Participants

One hundred and thirty six adults volunteered to participate in this experiment, of which 72 were young adults aged 18-47 years (M = 21.18, SD = 5.201) and 64 were older adults aged 58-90 years (M = 71.17, SD = 7.204). The younger adults were all students at the University of Reading who were recruited opportunistically through various means, including verbal request and the School of Psychology and Clinical Language Sciences Research Panel. Students recruited through the School Panel received course credit for their participation. The older adult participants were recruited through the School's Older Adult Panel of volunteers from the local community who were reimbursed for the cost of travelling to the University and received a small remuneration (£5) for their participation.

It was made clear that potential participants would not be excluded on the grounds of age, gender, disability, or first language. However, participants with a self-reported history of psychiatric, neurological or alcohol problems, or probable dementia on the bases of the Mini-Mental State Examination (i.e. a score of 24 or less; Folstein, Folstein & McHugh, 1975), were excluded. No participant was excluded on these grounds.

Although the younger adults had spent relatively more years in full-time education than the older adults, this difference was not significant, $p > .05$ (younger adults: range = 13-21, M = 14.92, SD = 1.581; older adults: range = 8-23, M = 14.08, SD = 3.925)].

Design

A between subjects design was employed with three factors: Age (younger, older adults), Method of Encoding (verbal, enactment) and Cue-Action Relatedness (related, unrelated). The effect of these variables was examined on three measures: PM performance (proportion of PM cues responded to correctly), performance accuracy on the ongoing word-sorting task, and response latency to non-PM cue items on the ongoing task.

Materials

The experimental session involved a practice phase for the ongoing task, followed by instructions for the PM task, a filled delay period and the main ongoing task containing the PM cues. The ongoing task was a computer-based activity in which participants had to sort a series of nouns into one of two different categories (natural or man-made). A version with 20 nouns was prepared for a practice phase. For the main ongoing task a set of 100 nouns (94 new and 6 cue words) was created. For the PM cue-action pairings two lists of 6 noun-verb pairs were compiled: one list comprised 6 related noun-verb pairs and the other 6 unrelated pairs. For the related list noun-action words with a moderate semantic association (FSG < 0.1; Nelson, McEvoy & Schreiber, 1998) were selected. These were: ball – throw; coat – hang; flower – smell; lemon – squeeze; needle – prick; pencil – sharpen. In the unrelated list the nouns from the related list were re-assembled with the verbs to create new pairs with no obvious associative relation between them: (e.g. ball – hang). The word pairs had normative medium values of familiarity (range = 3.71 – 4.59 on a scale of 1 to 7) and memorability (range = 3.71 to 3.34 on a scale of 1 to 7); Molander and Arar (1998).

Procedure

Participants were tested individually. They were informed that the session started with a practice task involving a simple computer-based activity in which they would have to allocate 20 different words into one of two different categories - natural or man-made - by pressing the appropriate key on the computer keyboard (‘z’ for manmade and ‘/’ for natural). Items remained on screen until the participant produced a response. This was followed by instructions relevant to the prospective task. Participants were presented with a set of 6 cue-action word pairs to learn. These formed the content of the prospective memory task. Half of the participants were presented with the 6 related cue-action pairs and the remainder were presented with the 6 unrelated cue-action pairs. In the verbal encoding condition, the 6 cue-action pairs appeared on the computer screen, one at a time and participants were asked to read each one aloud.

Participants in the enactment encoding condition were given the same information. However, in addition to reading the instructions aloud they were asked to physically perform the action on the imagined designated object. This encoding procedure was repeated twice to ensure adequate learning of the cue-action pairs.

All participants were informed that they would later be asked to perform a word-sorting task similar to the one performed during the practice phase. They were told that they would see a fixation cross in the centre of the computer screen for 3 seconds and that this would be followed by a sequence of words presented one at a time. As in the practice phase, participants were asked to decide if words belonged to the category “man-made” or “natural”, by pressing the appropriate computer key. They were then provided with the instructions for the prospective memory task. Specifically, they were informed that if they saw a previously presented object (cue) word, from any one of the six word-pairs that they had learned, then they should press the computer key “T” and to say aloud the second word of that pair (i.e. the action). After this they should continue the word-sorting task by pressing the appropriate key to indicate whether the object was natural or man-made.

Following provision of the prospective memory task instructions, participants were asked to complete unrelated questionnaires for a period of 5 minutes. Instructions for the main word-sorting (ongoing) task were then re-presented. However, no reminder of the prospective memory task was given on this occasion. The 100 words (96 new, 6 PM cues) of the word-sorting task were then presented. Items remained on screen until the participant made a key press response. In this word set the cue words were presented in the 8th, 20th, 44th, 55th, 82nd, and 99th position to ensure that they were relatively evenly spread across the set in such a way that a participant could not easily anticipate the exact position in which the next cue would appear. On completion of the word-sorting task participants were asked if they remembered the instructions that had been given to them by describing what they had been asked to do and recalling as many of the 6 cue-action word pairs as possible.

Results

All data were analysed using a 2 x 2 x 2 ANOVA, with Cue-Action Relatedness (related, unrelated), Method of Encoding (verbal, enactment), and Age Group (young, older) as between-subject factors, unless noted otherwise.

Prospective memory performance

The effects of Method of Encoding, Cue-Action Relatedness and Age on prospective memory performance were examined first. The mean proportion of cues that elicited a correct response at the appropriate moment in each Method of Encoding x Cue-Action Relatedness x Age Group condition was calculated, and is displayed in Figure 1.

Figure 1 about here

There was a reliable main effect of Cue-Action Relatedness; $F(1,68) = 22.01$, $p < .01$, $\eta_p^2 = .15$. As expected, prospective memory performance was better for cue-action pairs in which the cue was semantically associated with the action (M = .81, SD = .20) than for pairs in which the cue and action were not semantically related (M = .65, SD = .23). There was also a reliable main effect of Method of Encoding, $F(1,68) = 8.57$, $p < .01$, $\eta_p^2 = .06$, with superior PM performance when enactment was used at encoding (M = .78, SD = .18) than when the encoding was only verbal (M = .68, SD = .25). The main effect of Age Group was also reliable, $F(1,68) = 18.32$, $p < .01$, $\eta_p^2 = .13$, with superior PM performance for younger adults (M = .80, SD = .19) than for older ones (M = .66, SD = .24). There were no reliable interactions; all Fs $(1,68) < 1.02$, all η_p^2s $< .01$).

Prospective memory performance conditional on retrospective recall of PM task content

Maylor et al. (2002), among others, have suggested that participants may perform poorly in a PM task, not necessarily because of a PM failure but because of a retrospective memory failure i.e., failure to recall the content of the PM task. As Table 1 illustrates, most participants correctly recalled all 6 cue-action word pairs on completion of the ongoing task. A further 2 x 2 x 2 between subjects ANOVA conducted on these data revealed that the proportion of cue-action words recalled differed across Age Groups, $F (1,68) = 12.26$, $p < .01$, $\eta_p^2 = .09$, with superior PM performance for younger adults ($M = .97$, $SD = .08$) than for older ones ($M = .90$, $SD = .14$). However, no other significant main effects or interactions were identified; all $Fs < 2.38$, all η_p^2s $<.02$.

Table 1 about here

Although the current data indicate good retrospective memory for cue-action word pairs we decided to re-analyse the PM data using only those cue-action pairs that were accurately recalled after the task. The mean proportion of intended action words produced at the appropriate moment in the PM task was calculated for each experimental condition, excluding any items that were not remembered retrospectively. These data are displayed in Figure 2.

Figure 2 about here

There was a reliable main effect of Cue-Action Relatedness, $F(1,68) = 19.41$, $p < .001$, $\eta_p^2=.13$. As in the previous analysis, PM performance was better for semantically associated cue-action word pairs ($M = .85$, $SD = .22$) than for pairs in which the cue was not semantically associated with the action ($M = .69$, $SD = .22$). There was also a reliable main effect of Method of Encoding, $F (1,68) = 8.89$, $p < .01$, $\eta_p^2=.07$, revealing better PM performance when enactment was used ($M = .82$, $SD = .20$) than when encoding was only verbal ($M = .71$, $SD = .26$). A significant effect of age was also observed, $F (1,68) = 3.93$, $p = .05$, $\eta_p^2=.03$, such that older adults' performance was poorer (M = .73, SD = .28) than that of their younger counterparts (M = .80, SD = .18). As before, no reliable interactions were identified, all Fs < .62, all η_p^2s < .01. This pattern is identical to that observed when recall of cue-action pairs was not taken into account and suggests that the effects of semantic relatedness and enactment on PM are unlikely to be mediated by differences in retrospective memory for intention content.

Reaction Times and Performance Accuracy on the Ongoing Task

This study was not specifically designed to examine the cost to the ongoing task as we did not include a control condition in which the PM cues were neither included nor expected to appear (cf. Smith, 2003). However, by examining the possible influence of encoding modality and cue-action relatedness on ongoing task performance we can gain some insight into the relative strategic demands of the PM task across conditions. This enables us to make a preliminary investigation of the proposal that semantic relatedness and enactment at encoding might facilitate PM performance by reducing the demand for strategic processing to monitor for and respond appropriately to the cues.

Table 2 about here

Table 2 displays the mean proportion of correct responses made on the ongoing task along with the mean time taken to respond on ongoing task trials (excluding the time taken to react to the PM cues and the two items following a PM cue). There was no influence of Modality of Encoding or Cue-Action Relatedness on either the speed or accuracy of responses on the ongoing task, nor was there a significant interaction between these two factors on either latency or accuracy; both Fs < 2.62, all η_p^2 < .020. However, a significant main effect of Age on speed of response on the ongoing task was obtained, F (1,68) = 14.23, p < .001, η_p^2 =.10, with younger adults responding faster (M = 1043, SD = 310) than older ones (M = 1249, SD = 325). In contrast, there was no significant effect of age on ongoing task accuracy; F (1,68) = .116, ηp2=.001. There were no significant interactions between Age and Modality of Encoding or Cue-Action Relatedness, for both latency and accuracy; all Fs < 1.89, all η_p^2 < .015.

Discussion

In this experiment we set out to explore the benefits of cue-action relatedness and method of encoding on the prospective memory performance of younger and older adults. Our findings demonstrate that the benefits of enactment at encoding that have been observed in retrospective memory are present also for prospective memory performance, for both younger and older adults. Consistent with previous findings prospective memory performance was also better for related than for unrelated cue-action word pairs. Importantly, the advantage conferred by related pairs was observed for both younger and older adults. Moreover, in contrast to Kormi-Nouri's findings with a retrospective cued recall task, there was no significant interaction between cue-action relatedness and method of encoding; PM performance following enactment was not more beneficial for unrelated than for unrelated cue-action pairs. This finding, however, is consistent with other studies that have employed a cued recall task (Engelkamp & Jahn, 2003; Feyereisen, 2009).

We predicted that older adults would benefit from the enactment of related cue-action intentions at encoding such that greater age-related decrements would be observed when unrelated cue-actions intentions were encoded verbally. Our findings do not provide evidence consistent with this proposal. Both younger and older adults benefited from enactment and cue-action relatedness and although overall younger adults outperformed their older counterparts, age did not moderate these effects. One explanation for the absence of greater age-related decrements with either verbal encoding or unrelated cue-action word pairs is that successful performance on our PM task did not require a significant input of strategic resources. This is surprising in view of the overall age-related decrement in prospective memory performance and the fact that our task was relatively challenging with respect to number of (different) cue-action pairs that we employed (cf. Cohen, Jaudas & Gollwitzer, 2008). However, it is consistent with our failure to observe any reliable effects of either encoding strategy or cue-action relatedness on response latencies to the ongoing task. It is important to note that this observation is subject to an important caveat as in contrast to previous studies we did not employ a control condition in which the ongoing task is performed in the absence of a PM task and thus our measurement of task interference costs is a arguably a less sensitive assessment of these costs. This omission is addressed in the following study with younger adults only.

Experiment 2

In Experiment 1 we took the opportunity to investigate the relative 'costs' of performing a PM task, on ongoing task latency and accuracy, as a function of encoding modality and cue-action relatedness. Here, we investigate these ongoing task costs more directly by including a control condition in which the PM is absent (cf. Smith, 2003).

According to the PAM (preparatory attentional and memory processes) model resource-demanding attentional processes are required for successful PM task performance (Smith, 2003; Smith & Bayen, 2004). These demands were revealed by the observation that response latencies to ongoing task events are greater when a PM task is included than when it is absent. Subsequent research, however, indicates that the observation of these costs may be mediated by several variables including the number of target events (Cohen et al, 2008) and the nature of the ongoing task (Einstein & McDaniel, 2005). Using an ongoing lexical decision task Cohen et al (2008), for example, observed significant ongoing task costs only when three or more target words were employed as PM cues. Here, as in our previous study, we not only employ six target words but also link each target with a different 'action' word. Therefore we expect to observe a main effect of PM task presence such that ongoing task response latencies are greater when the PM task is present. In addition, we explore the possibility that this methodology will reveal greater costs after verbal encoding and when cue-action word pairs are unrelated.

Method

Participants

Seventy-two young adults aged 18-39 years (M = 19.72, SD = 2.39) volunteered to participate in this experiment. All were students at the University of Reading who were recruited opportunistically through various means, including verbal request and the School Research Panel. Students recruited through the School Panel received course credit for their participation. The participants had spent a mean of 14.73 years in full-time education (range = 11-19 years; SD = 1.30).

Design

A between subjects design was employed with three factors: Method of Encoding (verbal, enactment), Cue-Action Relatedness (related, unrelated), and PM task (present, absent). The influence of encoding modality and cue-action relatedness on prospective memory performance was examined using data from the PM-present conditions only.

The effects of these variables on the attentional demands of the PM task were examined using two measures: performance accuracy on the ongoing word-sorting task and response latency to non-PM cue items on the ongoing task.

Materials and Procedure

The materials were identical to those described for Experiment 1. The PM-absent condition followed the same general procedure as Experiment 1, with the exception that participants were not given instructions for the PM task and consequently they did not have to perform this task while completing the ongoing task. However, participants in the PM-absent condition were asked to learn the 6 noun-verb word pairs (either verbally or by enactment) and told that they would be asked to recall them after completing the word-sorting task. Participants in the PM-present condition followed the procedure employed in Experiment 1.

Results

Prospective memory performance

The effects of encoding method and cue-action relatedness on PM performance (i.e., number of cues eliciting a response irrespective of subsequent retrospective recall of cue-action pairs) was examined for participants in the PM-present condition using a 2 x 2 between subjects ANOVA.

As Table 3 illustrates, there was a main effect of encoding condition, $F(1,60) = 7.87$, $p < .01$, $\eta_p^2 = .12$, with superior performance following enactment ($M = .85$, $SD = .14$) than after verbal encoding ($M = .72$, $SD = .22$) . There was also a main effect of relatedness, $F(1, 60) = 4.43$, $p < .05$, $\eta_p^2 = .07$, such that more PM responses were made to related cue action pairs ($M = .83$, $SD = .18$) than to unrelated pairs ($M = .74$, $SD = .19$). The interaction between encoding modality and cue-action relatedness was not significant; $F < 1$.

- Insert Table 3 here -

A similar pattern was observed when PM performance was considered for only those items that were successfully recalled at the end of the ongoing task (i.e. conditional PM; see Table 3). Enactment at encoding resulted in better PM performance ($M = .86$, $SD = .13$) than verbal encoding ($M = .76$, $SD = .21$), $F(1, 60) = 5.70$, $p < .05$, $\eta_p^2 = .09$, and related pairs ($M = .86$, $SD = .17$) were associated with better PM performance than unrelated ($M = .75$, $SD = .19$); $F(1, 60) = 6.42$, $p <.05$, $\eta_p^2 = .10$. Again, these two factors did not interact; $F(1, 60) = 1.61$, $p = .21$, $\eta_p^2 = .03$. These findings clearly replicate the results observed in Experiment 1.

Reaction Time on the Ongoing Task

The effects of Method of Encoding, Cue-Action Relatedness and PM task presence on accuracy and mean latency on the ongoing task were analysed using two 2 x 2 x 2 between-subjects ANOVAs. The mean reaction time taken by participants to respond on ongoing task trials (excluding the time taken to react to the PM cues and to the two items immediately following a PM cue) was calculated for each experimental condition. As Table 4 illustrates, there was a reliable main effect of PM task; $F(1,120) = 48.860$, $p < .001$, $\eta_p^2 = .29$. As anticipated, the time taken to respond to ongoing task trials was considerably faster when the PM task was absent ($M = 798$, $SD = 169$) than when it was present ($M = 1049$, $SD = 226$). There were no other reliable main effects or interactions; all $Fs < .883$, all $ps > .349$, all $\eta_p^2 < .008$.

- Table 4 about here –

Performance Accuracy on the Ongoing Task

The proportion of items correctly sorted into the natural or manmade category was calculated separately for each experimental condition. As Table 4 illustrates, a between-subjects ANOVA performed on these data revealed a reliable main effect of Type of Cue-Action pair: $F(1,120) = 3.965$, $p < .05$, $\eta_p^2 = .03$. Unexpectedly, performance on the ongoing task was less accurate when the cue-action word pairs were related (M = .90, SD = .13) than when they were unrelated (M = .92, SD = .10). There were no significant effects of either Method of Encoding or of PM task on ongoing task accuracy; both Fs < 2.153; all ps > .145, all $\eta_p^2 < .02$). There were also no significant interactions; all Fs < 3.051; all ps > .083, all $\eta_p^2 < .03$).

- Table 5 about here –

Instructions Remembered after Performance of the Task

The proportion of cue-action word pairs accurately remembered after performing the word sorting task was calculated, and a between-subjects ANOVA performed on these data yielded a reliable main effect of Method of Encoding: $F(1,120) = 13.494$, p.< .001, $\eta_p^2 = .10$ (see Table 5). As anticipated, the number of correctly recalled cue-action word pairs was greater after enactment at encoding (M = .99, SD =.05) than after verbal encoding (M = .93, SD = .12). Furthermore, there was a reliable main effect of PM task: $F(1,120) = 4.015$, $p < .05$, $\eta_p^2 = .03$. Word pair recall was better when the PM task was present (M = .97, SD = .09) than when it was absent (M = .94, SD = .10) from the ongoing task. There was no significant effect of Cue-Action relatedness, $F < 1$, $p > .5$, $\eta_p^2 < .001$), and no significant interactions (all $Fs < 2.788$; all $ps > .098$, all $\eta_p^2 < .03$).

Discussion

As in the previous experiment, our findings reveal the beneficial effects of enactment at encoding and related cue-action word pairs on prospective memory performance, in the absence of a significant interaction of encoding modality and cue-action relatedness. In addition, the inclusion of a PM task led to a significant cost on ongoing task response latencies, a cost which, contrary to expectations, was not moderated by either encoding modality or cue-action relatedness. The implications of these findings alongside those observed in Experiment 1, are considered in more detail below.

General Discussion

The results from two experiments have demonstrated that the benefits of enactment over verbal encoding that have been observed in retrospective memory are apparent also in prospective memory. Moreover, the beneficial effects of enactment at encoding were observed in both younger and older adults. Additionally, the results provide further support for the benefits of cue-action relatedness on PM performance and extend previous research by revealing that older as well as younger adults' performance is enhanced by cue-action relatedness. Our findings may also have some interesting implications for the lively debate on the degree to which prospective memory performance necessarily relies on the deployment of strategic resources (see, for example, Einstein & McDaniel, 2010; Smith, Hunt, McVay & McConnell, 2007).

The absence of any age-related differences as a function of encoding modality and cue-action relatedness (Experiment 1) and the failure to observe any significant modulation of ongoing task costs as a consequence of these factors (Experiment 2, cf. McDaniel et al, 2000) is consistent with Smith's (2003) PAM model of the relationship between the allocation of strategic resources to support prospective remembering. In contrast, they do not appear to be consistent with the proposal that task characteristics influence the requirement for strategic resources to support successful PM performance (cf. McDaniel & Einstein, 2008); neither enactment at encoding nor a high degree of cue-action relatedness necessarily resulted in reduced or negligible costs on strategic resources. Moreover, this pattern of findings was observed when a relatively high number of PM cue-action pairs are specified; a situation which would be expected to require the recruitment of strategic resources (cf. Cohen et al, 2008).

An alternate or perhaps additional possibility may be pertinent here, in view of the number and nature of cue-action pairs that we employed in both experiments. We created and presented six different cue-action pairs, in an attempt to avoid the possible effects of repetition of individual pairs. This is unusual in prospective memory experiments where common practice is to (a) employ fewer than 6 cue-action pairs and, perhaps more importantly (b) specify different cues that each require the performance of the same action. In contrast we asked our participants to encode six different cue-action pairs (McDaniel et al used two different cue-actions pairs that were repeated twice).

According to the attention allocation proposal advanced by Marsh et al (2005), the deployment of attentional resources to a PM and its ongoing task may be determined by the individual at the outset through access to their meta-cognitive awareness of their prospective memory abilities and their perceived assessment of the characteristics and difficulty of this task (see also, Meeks, Hicks & Marsh, 2007). Under this account, the requirement in these experiments to encode six different cue-action pairs may have contributed to the perception that a relatively large amount of strategic resources would be required to successfully complete the PM task. This, in turn, may have encouraged the allocation of more strategic resources to support PM performance, irrespective of the type of encoding or the degree of cue-action relatedness and thus lead to general costs to the ongoing task irrespective of the experimental condition. Consistent with this argument, as noted earlier, Cohen et al (2008) observed significant costs when three or more cues were used. Moreover, each of their cues was linked with an identical action and thus the demand for strategic resources is arguably lower than those required in the present experiments.

Conclusion

We have demonstrated the benefits for PM performance of cue-action relatedness and the enactment of a cue-action pair for both young and older adults. Moreover, in investigating the occurrence of interference costs on the ongoing task, we have observed that successful PM performance appears to require the allocation of strategic resources. This finding may explain at least in part the observation of a general age-related decrement in performance for older adults. Importantly, however, we failed to reveal any modulation of these interference costs as a function of differences in either cue-action relatedness or encoding modality. This pattern of findings appears to be consistent with Smith's (2003) proposal that strategic resources are required for prospective remembering. However, an alternate possibility is that the overall demands of the PM task may have influenced the 'attentional allocation policy' that participants adopted prior to task performance, through an increase in the allocation of resources to support PM performance (Marsh, Hicks & Cook, 2005).

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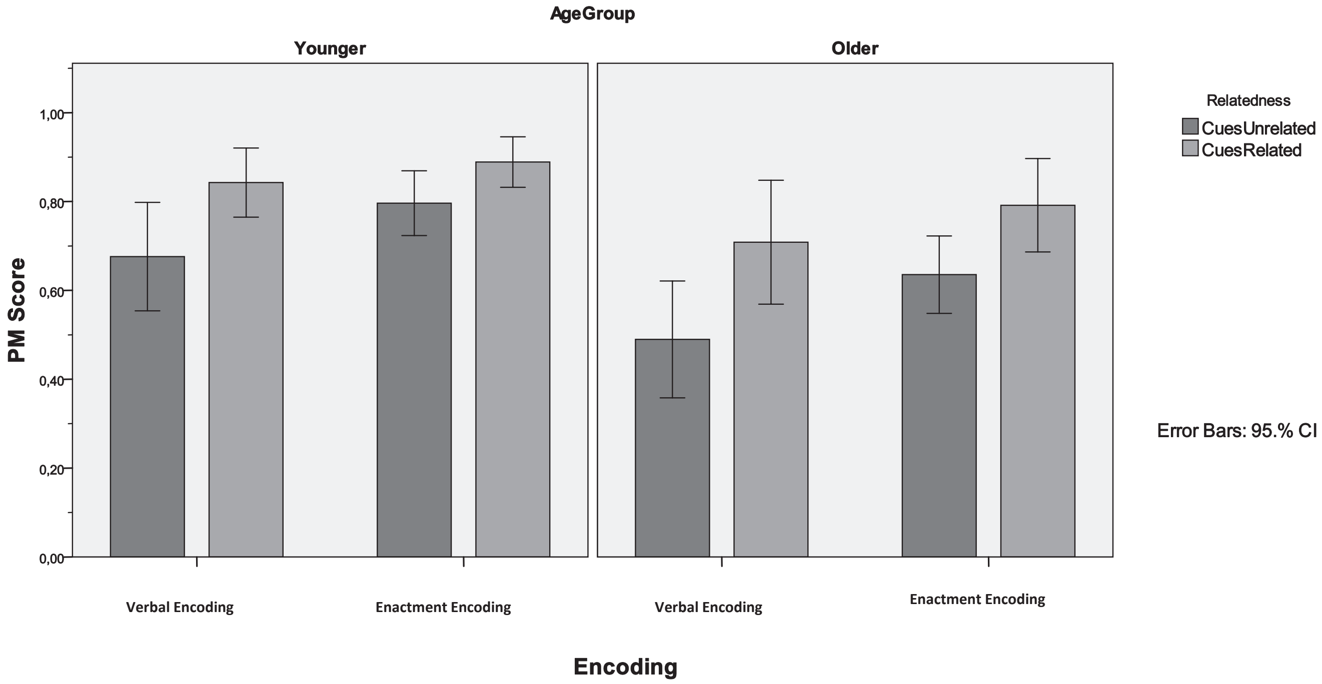
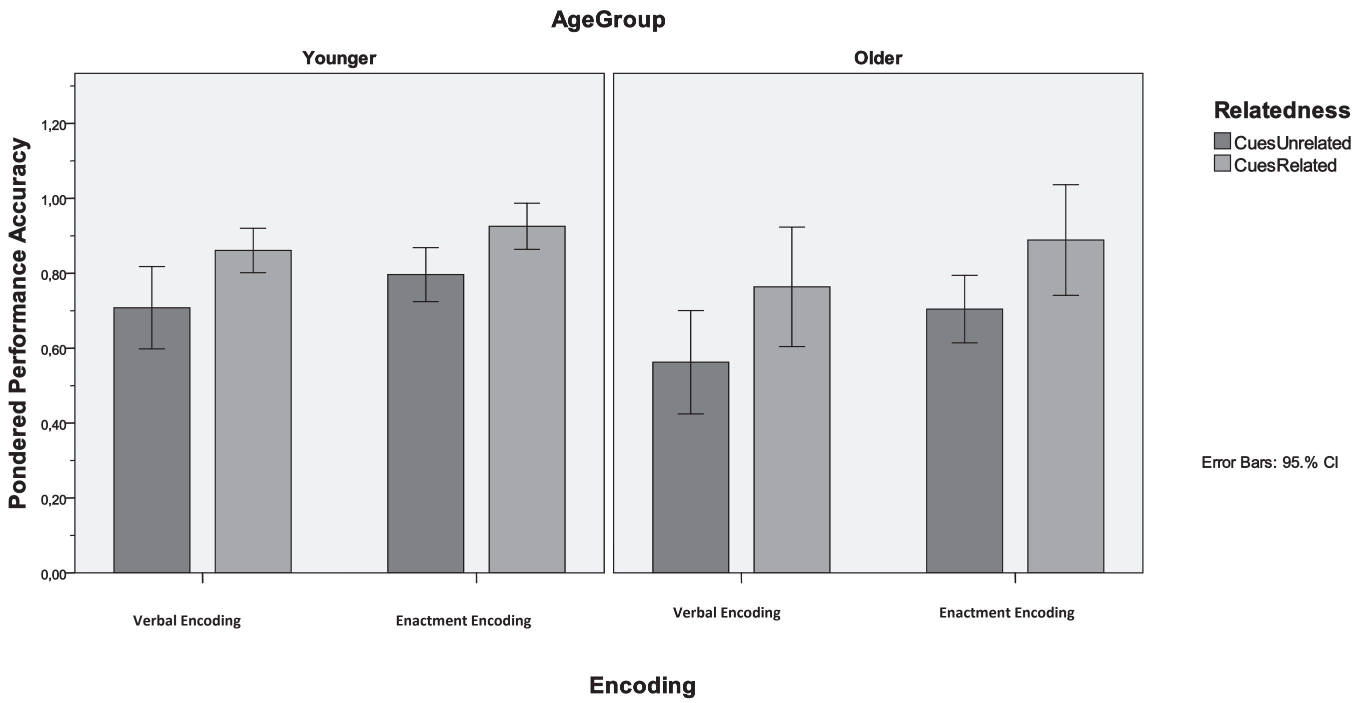

AgeGroup
Younger
Older
Relatedness
CuesUnrelated
CuesRelated
PM Score
1,00
0,80
0,60
0,40
0,20
0,00
Error Bars: 95.% CI
Verbal Encoding
Enactment Encoding
Verbal Encoding
Enactment Encoding
Encoding

Figure 1. Mean proportion of PM cues eliciting a correct response at the appropriate moment in each Method of Encoding X Cue-Action Relatedness condition for young and older adults


AgeGroup
Younger
Older
Relatedness
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Error Bars: 95.% CI
Pondered Performance Accuracy
0,00
0,20
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0,60
0,80
1,00
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Verbal Encoding
Enactment Encoding
Verbal Encoding
Enactment Encoding
Encoding

Figure 2. Mean proportion of correct PM responses for cue-action pairs remembered after the task in each Method of Encoding X Cue-Action Relatedness condition for young and older adults

Table 1. Mean proportion (and Standard Deviation) of cue–action words pairs recalled after completion of the ongoing task in each Method of Encoding X Cue-Action Relatedness condition for young and older adults

	Verbal encoding		Enactment at encoding	
	Related pairs	Unrelated pairs	Related pairs	Unrelated pairs
Older Adults	.93 (.14)	.86 (.15)	.92 (.14)	.91 (.12)
Younger Adults	.97 (.09)	.94 (.11)	.96 (.07)	1 (0)

Table 2. Mean response time (and Standard Deviation) in milliseconds and mean proportion of correct responses (and Standard Deviation) on the ongoing task in each Method of Encoding x Cue-Action Relatedness condition for young and older adults

	Verbal encoding		Enactment at encoding	
	Related pairs	Unrelated pairs	Related pairs	Unrelated pairs
Response times				
Young adults	940 (21)	1100 (31)	1090 (45)	1090 (25)
Older adults	1310 (34)	1190 (23)	1270 (43)	1290 (30)
Accuracy				
Young adults	.93 (.11)	.87 (.13)	.92 (.13)	.92 (.12)
Older adults	.94 (.08)	.88 (.17)	.90 (.13)	.91 (.15)

Table 3. Mean proportion (and Standard Deviation) of raw and conditional PM responses in the ongoing task in each Method of Encoding x Cue-Action Relatedness condition for PM-present participants.

	Verbal encoding		Enactment at encoding	
	Related pairs	Unrelated pairs	Related pairs	Unrelated pairs
Raw PM performance	.78 (.05)	.67 (.05)	.89 (.05)	.81 (.05)
PM conditional on retrospective recall	.84 (.04)	.68 (.04)	.89 (.04)	.83 (.04)

Table 4. Mean response time (and Standard Deviation) in milliseconds and mean proportion of correct responses (and Standard Deviation) on the ongoing task in each Method of Encoding X Cue-Action Relatedness for PM-present and PM-absent participants

	Verbal Encoding		Enactment at Encoding	
	Related pairs	Unrelated pairs	Related pairs	Unrelated pairs
Response times				
PM Present	1020 (15)	1080 (19)	1050 (18)	1090 (35)
PM Absent	770 (09)	820 (16)	830 (24)	820 (17)
Accuracy				
PM Present	.94 (.05)	.96 (.02)	.92 (.12)	.91 (.12)
PM Absent	.84 (.16)	.93 (.07)	.89 (.14)	.95 (.02)

Table 5. Mean proportion (and Standard Deviation) of cue–action words pairs recalled after completion of the ongoing task in each Method of Encoding X Cue-Action Relatedness for PM-present and PM-absent participants

	Verbal Encoding		Enactment at encoding	
	Related pairs	Unrelated pairs	Related pairs	Unrelated pairs
PM Absent	.91 (.10)	.90 (.13)	.99 (.04)	.98 (.06)
PM Present	.94 (.15)	.98 (.06)	1 (0)	.98 (.06)

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Figure

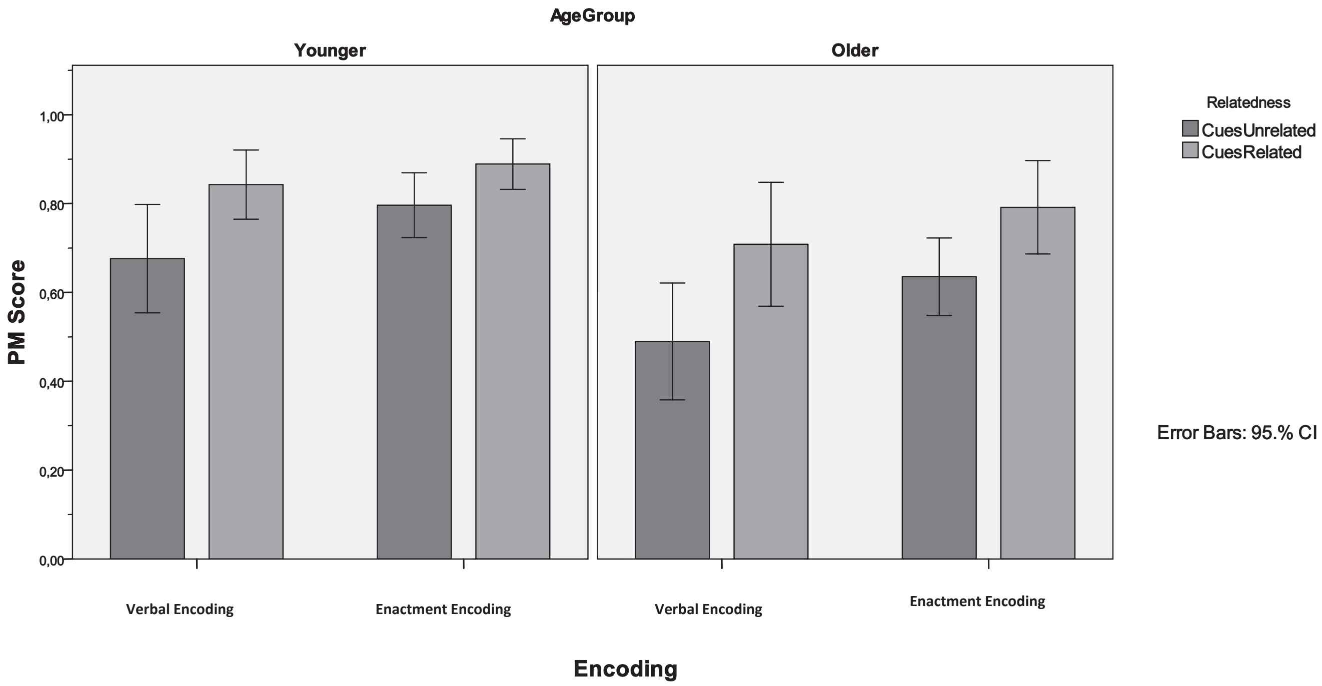
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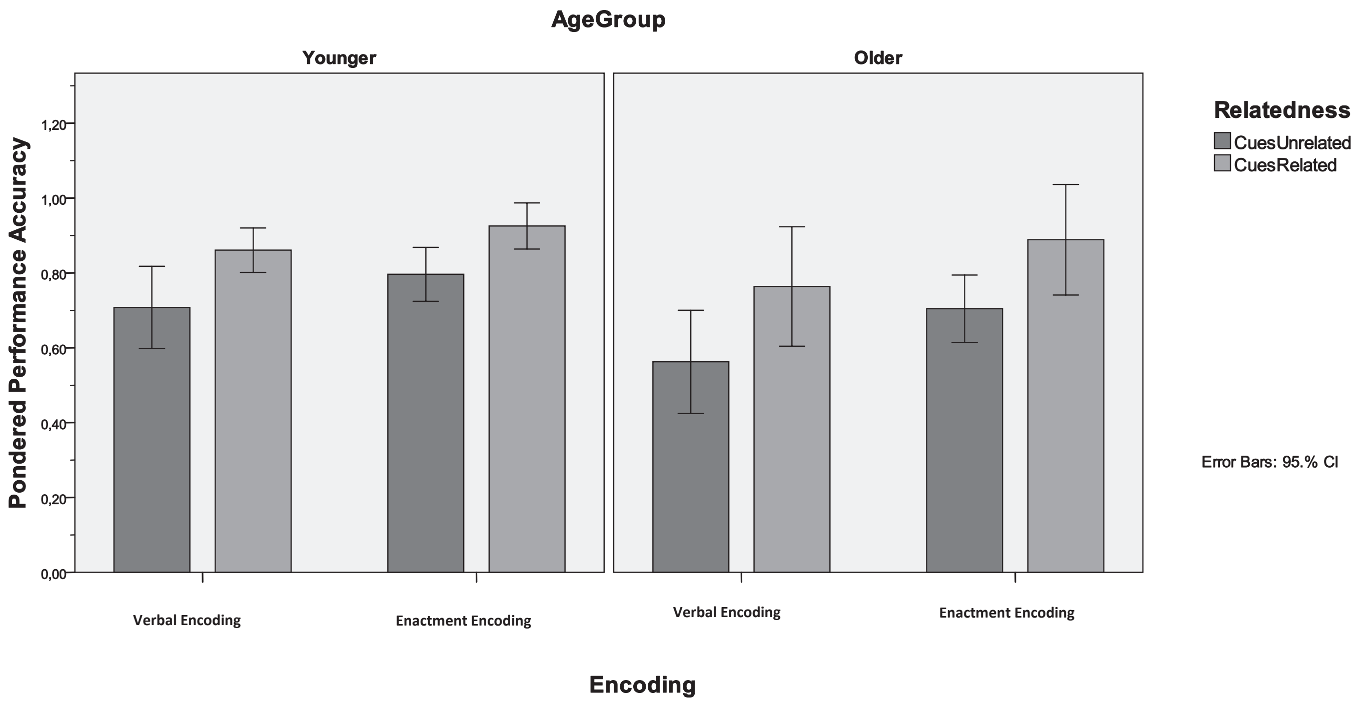
Figure


AgeGroup
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