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# Habitual prospective memory in schizophrenia

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## Abstract

**Background:** Prospective memory (PM), the act of remembering that something has to be done in the future without any explicit prompting to recall, provides a useful framework with which to examine problems in internal-source monitoring. This is because it requires distinguishing between two internally-generated processes, namely the intention to perform an action versus actual performance of the action. In habitual tasks, such as taking medicine every few hours, the same PM task is performed regularly and thus it is essential that the individual is able to distinguish thoughts (i.e., thinking about taking the medicine) from actions (i.e., actually taking the medicine).

**Methods:** We assessed habitual PM in patients with schizophrenia by employing a laboratory analogue of a habitual PM task in which, concurrently with maneuvering a ball around an obstacle course (ongoing activity), participants were to turn over a counter once during each trial (PM task). After each trial, participants were asked whether they had remembered to turn the counter over.

**Results:** Patients with schizophrenia made a disproportionate number of errors compared to controls of reporting that a PM response had been made (i.e., the counter turned over) after an omission error (i.e., the counter was not turned over). There was no group difference in terms of reporting that an omission error occurred (i.e., forgetting to turn over the counter) when in fact a PM response had been made.

**Conclusion:** Patients with schizophrenia displayed a specific deficit distinguishing between two internally-generated sources, attributable to either poor source monitoring or temporal discrimination.

## Background

Prospective memory (PM) may be defined as remembering that something has to be done at some point in the future, without any prompting in the form of explicit recall instructions. PM has become of increasing interest to psychologists and neuropsychologists because of its central importance in maintaining function in everyday life, such as remembering to take one's medicine every few hours. PM contrasts with retrospective memory (RM) in which one remembers information from the past, such as remembering the name of the new patient who has just been admitted to the ward. Clearly all PM tasks have an RM component (see [1] for discussion). For instance, one could fail the PM task of passing a message on to a friend

when you next see him/her either because of forgetting the intention to pass on the message (a PM failure) or because of forgetting the details of the message (an RM failure). However, the usual goal of PM studies is to minimize the RM component, such that task performance is predominantly determined by PM (for a review, see [2]). It is probably of most use to envisage PM as referring to a set of behaviors (including non-mnestic cognitive processes) that enable one to realize a delayed intention, rather than as a separate memory module (see [3,4]). Performance on a PM task typically includes the encoding of an intention, retaining the information, executing the intention, and then evaluating the outcome (this last component being the primary focus in the current study).

Patients with schizophrenia present with a wide range of cognitive deficits, especially in the domain of memory (for reviews, see [5–7]). PM is of interest here because it represents a possible framework (and one that is ecologically based) within which to examine the possible contribution of memory processes that are thought to be compromised in schizophrenia. Confusion about the source of an action or a thought has been suggested to underlie some symptoms observed in schizophrenia (e.g., [8–11]). Furthermore, it has been shown that there is a relationship between reality monitoring errors and disorganized thinking in schizophrenia, with thought disordered schizophrenic patients experiencing problems differentiating information that they had spoken from that which they had merely thought [12]. Indeed, actions that are often thought about pose potential problems for internal-source monitoring. This is because one must be able to distinguish thoughts from actions. Previous studies in which schizophrenic patients have been required to judge whether processes were from an internal source versus from an external source found that patients, especially those with hallucinations, tend to misattribute internal events to external sources [13–18] [see also [19–22]]. Distinguishing between two internal sources should surely be a difficult task, and this may be especially the case in schizophrenia. Indeed, performance on a task that focuses only on distinguishing between two internally-generated sources may shed more light on whether the theoretical notion of confusion between actual and imagined events (see [23]) has empirical support in patients with schizophrenia.

By definition PM places a heavy demand on self-initiated retrieval in the absence of any external prompts or cues from the environment [1]. However, an important distinction has been drawn between time-based and event-based PM tasks [24], with the former placing heavier demands on self-initiated retrieval in comparison with the latter. This is because in time-based tasks, such as remembering to make a telephone call at 20:00, there are few environmental triggers and thus one has to monitor time effectively in order to respond at the appropriate moment; in contrast, in event-based tasks, such as remembering to make a telephone call when a television programme is over, one can rely on the target event itself acting as the cue to initiate PM performance. In the present study, we chose a time-based PM task in order to maximize the amount of self-initiated retrieval required by participants to perform successfully. Furthermore, we were interested specifically in habitual PM (such as taking medicines every 4 hours) in which the same PM task has to be done on a regular basis. In habitual PM tasks, such as the one employed in the current study (based on [2], which was itself adapted from [25]; see also [26]), the measure of interest is participants' ability to evaluate the outcome (i.e., whether or not the PM task has been carried out successfully).

Two main 'action' errors may arise in such a task: (1) omission errors – in which the PM task is not carried out, and (2) repetition errors – in which the PM task is incorrectly repeated. Omission errors may occur because of mistaking thinking about an action with the actual performance of the action (i.e., output/reality monitoring error [27]), or mistakenly thinking that one has performed an action because one erroneously recalls the memory of performing that action from a previous occasion (temporal discrimination error [28]). Repetition errors may arise because one forgets that one already performed that action (i.e., output/reality monitoring error), or because one might remember that one performed the action but attribute the memory to a previous occasion rather than to the current time (temporal discrimination error).

Evaluation of the outcome of a PM task can be investigated by asking the participant after a PM trial to say whether or not the action was successfully carried out on that trial. Thus there are two possible 'evaluation' errors: (1) If a PM response was not made (i.e., an omission error) but the participant incorrectly reported that the action was performed successfully, we denote this evaluation error as 'Action-no/Report-yes'. (2) If a PM response was made but the participant incorrectly reported that the action was omitted, we denote this evaluation error as 'Action-yes/Report-no'.

The first question of interest in the current study was whether there would be a deficit in patients with schizophrenia in comparison with normal healthy controls in the performance of a habitual PM task. Although we are unaware of any published studies of PM in schizophrenia, our prediction based on deficits in other memory domains was that action errors (i.e., omissions and repetitions) would be greater in the patients. The second

**Table 1: Characteristics of Patient and Control Samples**

| | Patients *n* = 20 (18 M, 2 F) | | Controls *n* = 20 (14 M, 6 F) | | Group Difference |
|---|---|---|---|---|---|
| | ***M*** | ***SD*** | ***M*** | ***SD*** | |
| Age (years) | 34.8 | 7.2 | 36.6 | 6.8 | $t(38) = 0.81$, $p > .1$ |
| WRAT-R IQ | 102.7 | 10.6 | 105.4 | 8.9 | $t(38) = 0.85$, $p > .1$ |
| WAIS-R IQ | 87.6 | 8.2 | 105.9 | 10.8 | $t(38) = 6.04$, $p < .001$ |
| Digit span: Total | 13.2 | 3.4 | 18.3 | 4.3 | $t(38) = 3.81$, $p < .001$ |
| Digit span: Forward | 7.1 | 1.8 | 9.2 | 2.4 | $t(38) = 3.03$, $p < .01$ |
| Digit span: Backward | 6.1 | 2.3 | 9.1 | 2.5 | $t(38) = 4.02$, $p < .001$ |
| Neuroleptic medication | 19 | | 0 | | |
| clozapine/olanzapine | 14 | | - | | |
| risperidone | 7 | | - | | |
| high potency drug* | 1 | | - | | |
| anticholinergics | 1 | | - | | |
| adjunctives** | 10 | | - | | |

* = haloperidol ** = lithium, depakote, sertraline, lorazepam, venlafaxine, clonazepam, buspirone

important question addressed here was whether the patterns of outcome evaluation errors would be different in patients with schizophrenia, as compared to healthy controls. Working memory is presumably crucial for holding the intended action in mind, scheduling the sequences of responses and monitoring the execution of those responses [29]. Patients with schizophrenia have been shown to have working memory problems [30–37]. Thus, we predicted that these patients would display problems concurrently holding in mind the PM task while conducting ongoing activity (which at some point has to be interrupted in order to execute the PM task) in addition to retaining information on the status of the PM task for subsequent outcome evaluation. We therefore expected greater numbers of evaluation errors (i.e., discrepancies between actions and reports of actions) in patients.

## Methods

### *Participants and Baseline Tests*

In- and out-patients from the National Institute of Mental Health research wards participated in this study ($n$ = 20). All patients fulfilled DSM-IV criteria for schizophrenia, as determined by the Structured Clinical Interview for DSM-IV (SCID) with three psychiatrists reaching a consensus diagnosis. Patients generally had multiple hospital admissions due to incomplete responses to conventional treatments. Normal healthy control volunteers were recruited through the National Institutes of Health volunteer panel ($n$ = 20). No participant, control or patient, with a history of traumatic brain injury, epilepsy, developmental disorder, diagnosable current substance dependence, or other known neurological condition was included in this study. All participants had normal or normal corrected vision. Control participants were paid for their participation. The study was approved by the internal review board at the National Institute of Mental Health and informed consent was obtained from all participants prior to testing.

Table 1 shows the mean ages and scores on background tests of the patients and controls, and the medication details for the patients. Two baseline tests were used to index intellectual function. The first was a test of reading proficiency – the Wide Range Achievement Test – Revised (WRAT-R [38]), which is widely used as a putative measure of premorbid intellectual functioning [39–41]. The second was a short version of the Wechsler Adult Intelligence Scale – Revised (WAIS-R [42]; see also [43,44]. The substantial drop in intelligence from estimated premorbid function that we observed is often reported in schizophrenia [45]. Digit span was assessed using the Wechsler Memory Scale-Revised [46].

### *Design and Procedure*

The ongoing activity was a commercial battery-powered game ("Kongman"; TOMY Toy Corporation, 1982) in which a steel ball was to be moved around an obstacle course by pressing a button at the appropriate time points in order to open or close certain routes through which the ball could travel. Each game lasted 90 seconds, and participants were instructed to accumulate as many points as possible during each game until the time was up. The game commenced by each participant winding a timer at the base of the game. During the course of the game the timer moved from the start to the finish position (taking 90 seconds). The rim surround of the timer was covered and colored with red and green colored paper, such that the first 25 seconds were red and the remaining 65 seconds green. The PM task was to turn a counter (a poker chip that was similar on both sides) over once during each game. However, participants were instructed to turn the

**Table 2: Mean Numbers and Standard Deviations of Action and Evaluation Errors in Trials 1-5 and 6-10 in Patients and Controls**

| | Patients | | | | Controls | | | |
|---|---|---|---|---|---|---|---|---|
| | Trials 1–5 | | Trials 6–10 | | Trials 1–5 | | Trials 6–10 | |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Action errors | | | | | | | | |
| Omissions | 1.70 | 1.45 | 1.45 | 1.82 | .25 | .55 | .15 | .37 |
| Repetitions | .45 | 1.19 | .65 | 1.27 | .45 | .60 | .60 | 1.14 |
| Evaluation errors | | | | | | | | |
| Action-no/ Report-yes | .75 | 1.21 | .60 | 1.39 | .10 | .31 | .10 | .31 |
| Action-yes/ Report-no | .10 | .31 | .20 | .52 | .10 | .31 | .05 | .22 |

counter over only when the timer reached the green zone (i.e., they could not respond prospectively immediately, but had to wait for some proportion of time into the game before responding). Participants were to play the game a total of 10 times (i.e., 10 trials). After each of the ten games, participants were asked if they had remembered to turn the counter over during the game. The experimenter employed a stopwatch to note the time at which the counter was turned over, and whether it was in the green or red zone. The participants' response to the question concerning whether they remembered to turn over the counter was also noted. The game was sufficiently easy and enjoyable that participants engaged in the game and all participants performed extremely well. Because this was merely the ongoing task in which the PM task was embedded, the points scored in the actual game were not formally analyzed.

## Results

The data from trials 1–5 were combined, as were the data from trials 6–10 (see [25] for a similar procedure). Numbers of action and evaluation errors were analyzed using analyses of variance (ANOVAs) with diagnostic group (patients vs. controls) as a between-subjects factor and trials (1–5 vs. 6–10) as the within-subjects factor. The overall means are summarized in Table 2.

First, we examined the numbers of action errors (omissions and repetitions) in the PM task. Concerning omission errors, there was a main effect of group, $F(1, 38) = 15.67$, $p < 0.001$, with patients making more omissions (i.e., failing to turn the counter over) than controls. There was no significant effect of trials, $F(1, 38) = 1.18$, $p > .1$, although there was a numerical decrease in omission errors across the first three trials (*M*s = 0.35, 0.20, and 0.13), with omission errors remaining relatively stable ($M = 0.16$) thereafter. The initial decrease is presumably due to the repeated reminder provided by the outcome evaluation question after each trial. There was no significant interaction between group and trials, $F < 1$. These findings were very similar when we examined omission errors more stringently as a function of whether the PM task of turning the counter was done only when the dial was in the green zone, with patients making omissions at an average rate of 0.36 per trial and controls at 0.05 per trial. We note that this low rate of omission errors in controls reduces the opportunity to report a missed action as having been performed (see later Discussion). For repetition errors in the PM task (i.e., turning the counter over more than once during the game), there was no significant difference between groups, $F < 1$, no effect of trials, $F(1, 38) = 1.12$, $p > .1$, and no Group × Trials interaction, $F < 1$.

Second, we examined the numbers of outcome evaluation errors for each participant (i.e., Action-no/Report-yes errors, and Action-yes/Report-no errors). Concerning Action-no/Report-yes errors, namely, reporting that a PM response had been made (i.e., counter turned over) after an omission error (i.e., the counter was not turned over), patients were significantly more likely to make such errors than controls, $F(1, 38) = 4.27$, $p < 0.05$. In other words, patients more frequently failed to perform the PM task, but upon questioning (i.e., evaluation) mistakenly stated that they had made their PM response. There was no significant effect of trials, $F < 1$, and no interaction between group and trial, $F < 1$. Action-yes/Response-no errors, which refer to reporting that an omission error occurred (i.e., forgot to turn the counter) when in fact a PM response had been made (i.e., the counter had been turned over) were quite rare in both groups with no significant difference between them, $F < 1$. There was no effect of trials, $F < 1$, and no interaction, $F < 1$.

Finally, we examined whether the significant group differences for numbers of omission and Action-no/Report-yes errors remained after taking into account measures of IQ and digit span (from Table 1) using analyses of covariance (ANCOVAs). For omissions, the group effect remained

significant at $p < .05$ in separate ANCOVAs with current IQ (WAIS-R), a putative index of premorbid IQ (WRAT-R), forward digit span and backward digit span as a covariate. In contrast, for Action-no/Report-yes evaluation errors, the significant group effect disappeared when either backward digit span or WAIS-R was included as a covariate ($p > .1$ for the group effects in both cases), but not when forward digit span or WRAT-R was included as a covariate ($p < .05$ and $p = .05$ for the group effects, respectively).

## Discussion

Many everyday memory tasks require PM, yet our understanding of this type of memory is greatly limited by the paradigms with which it can be studied. To our knowledge, this is the first study to show that schizophrenia is associated with an overall impairment in habitual PM performance. In our habitual PM task (based on [2], which itself was adapted from [25]), patients with schizophrenia were more likely to forget to perform the PM task than were controls. Note that all participants knew that they were to turn over the counter (and this was confirmed by questioning at the beginning and end of the experiment). In other words, they all knew (and remembered) what they were required to do, but patients simply more frequently forgot to do it at the appropriate time. Importantly, this action deficit could not be attributed to overall group differences in IQ or digit span. In contrast, the group effect for Action-no/Report-yes evaluation errors, whereby patients more often than controls reported that they turned the counter when they did not, was removed by covarying either current IQ or backward digit span. This relationship may be understood in the sense that when participants are asked whether they remembered to turn over the counter (the PM task) they have to sequentially scan their memory and arrange items in an order that enables them to respond to the question at hand. The close relationship of this evaluative (RM) component of PM to working memory is thus not surprising (cf. [29]), and nor its relationship to a decline in current intelligence in patients.

It should be recognized that the increase in Action-no/Report-yes errors seen in patients is at least partly a consequence of the group difference in omission errors. Indeed, control participants made very few omission errors at all; this may be regarded as a virtue as patients did make a non-trivial number of mistakes on a task that was fairly easy. Arguably, a preferable measure would be the probability of a "yes" report given that an omission had occurred – in other words, the number of Action-no/Report-yes responses conditionalized upon the number of opportunities for such responses (i.e., the number of omissions). It was not possible to compare such rates between patients and controls in the present study because of so few control participants ($n = 5$) making any omission errors. However, it is striking that, for patients, the mean probability of reporting that a PM response had been successfully executed following an omission error was 0.32 ($SD = 0.42$). (Three patients were excluded from this particular analysis because of no omission errors.) In other words, on approximately one-third of occasions on which patients failed to perform the PM task, they nevertheless reported (incorrectly) that they had done so. This would seem a worryingly high probability for such an apparently simple task that posed few problems for controls. Importantly, this result would suggest that patients' self-reports of having completed a habitual PM task (e.g., taking medication) are likely to be particularly unreliable. A future study assessing the ecological validity of a laboratory analogue of a habitual PM task may provide a useful indicator of the likelihood of individual patients correctly remembering to perform habitual PM tasks such as reliably taking their medications.

As in both Einstein et al.'s [25] study with older adults and Maylor et al.'s [2] study with young children, the reasons behind such increases in output evaluation errors remain unclear. Thus, one possibility is that patients reported "yes" after an omission error because of a failure to monitor the source, in the sense that patients thought about turning over the counter early on in the game before it was appropriate to respond, but then later attributed this thought to actually performing the action. Alternatively, patients' performance profiles may be indicative of a temporal discrimination problem in that they remembered a response from the previous game and thus thought that this was their response in the current game. It is of course also possible that patients have a general response bias to say "yes". In other words, the task is to do "something" and so when asked if they did so, they may say "yes" because that is what is expected. However, we have no a priori reason to assume any response bias would be qualitatively different to that in healthy control participants, and moreover it is unlikely given the absence of any reward (or feedback) conditional upon performance.

Source memory problems have been reported in normal aging (e.g., [47]), as have PM problems [48–50]. Interestingly, our current findings with schizophrenic patients are similar to those reported (from a different task) in patients with Alzheimer's disease (as well as older adults as compared with younger adults) in the sense that the PM failures were not due to forgetting the task instruction, but rather that patients failed more frequently to carry out the PM task as a response to the appropriate cue [51]. Taken together, these findings suggest that general cognitive decline may be associated with specific deficits in PM. Indeed, the frequent thoughts and executions of actions associated with PM tasks provide a useful empirical framework for future studies to examine source monitoring

problems that may underlie certain memory problems, as well as a variety of illusory memories, especially in patients who are often considered to be vulnerable to these errors. Interestingly, in situations that do encourage false or illusory memories we have not found schizophrenic patients to be disproportionately susceptible as compared to control participants (e.g., false recognition paradigm; Elvevåg et al. (2002); unpublished data). However, in our current study of PM in which participants had to distinguish between two internally-generated sources, we found that schizophrenic patients were more vulnerable to a specific memory error, namely, claiming to have completed a PM task when they have not in fact done so.

## Conclusions

In conclusion, PM provides an ecologically valid and straightforward framework within which one can explore the nature of problems that patients have when required to discriminate between two internally-generated processes. Future studies exploring the relationship of these discriminatory problems to symptoms and to measures of functional outcome promise to be informative regarding the clinical presentation and management of schizophrenia.

## Competing interests

None declared.

## Authors' contributions

BE participated in the study design, data collection and analysis and drafted the manuscript. EAM participated in the experimental design (which was adapted from, and used the same equipment as, that used in her previous work with children), and she contributed to the data analysis and the writing of the manuscript. ALG participated in the data collection and analysis of the study.

All authors read and approved this manuscript.

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