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Objective measures of prospective memory do not correlate with subjective complaints in schizophrenia

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Abstract

While a number of studies have shown that individuals with schizophrenia are impaired on various types of prospective memory, few studies have examined the relationship between subjective and objective measures of this construct in this clinical group. The purpose of the current study was to explore the relationship between computer-based prospective memory tasks and the corresponding subjective complaints in patients with schizophrenia, individuals with schizotypal personality features, and healthy volunteers. The findings showed that patients with schizophrenia demonstrated significantly poorer performance in all domains of memory function except visual memory than individuals with schizotypal personality disorder and healthy controls. More importantly, there was a significant interaction effect of prospective memory type and group. Although patients with schizophrenia were found to show significantly poorer performance on computer-based measures of prospective memory than controls, their level of subjective complaint was not found to be significantly higher. While subjective complaints of prospective memory were found to associate significantly with self-reported executive dysfunctions, significant relationships were not found between these complaints and performance on a computer-based task of prospective memory and other objective measures of memory. Taken together, these findings suggest that subjective and objective measures of prospective memory are two distinct domains that might need to be assessed and addressed separately.

Keywords: Schizophrenia; Schizotypal personality disorder; Prospective memory; Subjective cognition

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1. Introduction

Cognitive deficits are considered a core feature of schizophrenia. Empirical findings have shown that marked cognitive impairments are common in schizophrenia (Chan et al., 2006a,b; Heinrichs and Zakzanis, 1998) and can be found in up to 75% of patients (Goldberg et al., 1988). Although the majority of patients with schizophrenia are responsive to treatment of positive symptoms, their cognitive impairments are more long term and could lead to poor social and occupational outcomes (Aleman et al., 1999). Memory impairment is considered one of the most pervasive cognitive dysfunctions in schizophrenia (Aleman et al., 1999; Bilder, 1996; Goldberg and Gold, 1995; Heinrichs and Zakzanis, 1998; Pantelis et al., 1996).

Previous studies on memory dysfunction in schizophrenia have been focused on retrospective memory (e.g., Heinrichs and Zakzanis, 1998; Henry et al., 2007). Comparatively, little is known about the nature and magnitude of prospective memory deficits in this clinical group. Retrospective memory is the ability to recall from a past time point, whereas prospective memory is defined as the ability to perform an intended action at a particular point in the future (Craik, 1986; McDaniel et al., 2003). Prospective memory can be further classified into three subtypes: (a) event-based, where a person is required to perform an intended action on meeting certain persons or objects (acting as cues); (b) time-based, where a person is required to perform an intended action at an appropriate time point in the future; and (c) activity-based, where a person is required to carry out certain actions at the end of an ongoing activity (Einstein and McDaniel, 1990).

Prospective memory is considered crucial for patients to achieve and maintain an optimal level of functioning in daily living. Failures in prospective memory may lead to undesirable consequences and poor rehabilitation outcomes for patients with schizophrenia and other related disorders (Kurtz et al., 2001; Shum et al., 2001). For example, forgetting to turn up for a doctor's appointment, forgetting to pay bills, or forgetting to take medication on time can all have serious consequences for patients. A systematic database search (EBSCOhost, PsychINFO, PsyARTICLES, MEDLINE, and ScienceDirect) using the keywords "schizophrenia + prospective memory" and a manual search from the references, indicates that only nine studies of prospective memory in schizophrenia (Elvevag et al., 2003; Henry et al., 2007; Kondel, 2002; Kumar et al., 2005; Ritch et al., 2003; Shum et al., 2004; Twamley et al., in press; Wang et al., in press; Woods et al., 2007) have been published to date. Table 1 summarizes the major findings of these studies and the computed effect sizes of prospective memory deficit in schizophrenia as compared to healthy controls. Three of these studies (Kondel, 2002; Ritch et al., 2003; Twamley et al., in press) did not include a control group for comparison. Therefore, we could not estimate effect sizes for them. Despite the methodological limitations of some of these studies (e.g., including mainly chronic patients who were treated with a wide variety of atypical and typical antipsychotics), the results suggest that the effect size of prospective memory deficits in schizophrenic patients is generally large (Cohen's d ranges from 0.78 to 1.56). Henry et al. (2007) suggested that prospective memory impairment represents a primary deficits rather than a consequence of other cognitive deficits known to be affected in schizophrenia. Wang et al. (in press) demonstrated that these deficits were found in both clinical cases and non-clinical individuals with schizotypal personality features and suggested prospective memory can be considered a potential endophenotype of schizophrenia.

In addition to the performance of objective measures, subjective cognitive complaints can also be important for the early detection of schizophrenia. This is because these complaints precede prodromal symptoms and are therefore useful in predicting onset and relapse of schizophrenia (Klosterkotter et al., 2001; Nuechterlein and Dawson, 1984) as well as long-term symptomatic deterioration (Moritz et al., 2000). Further support comes from findings indicating that, without the corroboration of subjective measures, cognitive deficits detected by objective measures are not sufficient to accurately predict illness onset (e.g., Weiser et al., 2001). Therefore, subjective cognitive impairments can provide additional information for medical practitioners and researchers what conventional objective neuropsychological tests are unable to tell about the severity of clinical and functional outcomes of the patient. Subjective measures of cognitive function such as self-report questionnaires or related scales help to shed light on self-perceived cognitive difficulties in daily-life activities, which are otherwise unobservable behaviorally.

Further to our previous findings (Wang et al., in press), the purpose of the current study was to examine the relationship between computer-based prospective memory tasks and the corresponding subjective complaints in an independent sample of patients with schizophrenia. To achieve this aim, we adopted a comprehensive assessment of prospective memory in terms of time-, event- and activity-based tasks that originated from cognitive psychology. We also examined the subjective complaints of prospective memory using a psychometrically sound self-reported

Table 1
Summary of the effect sizes of prospective memory deficits in schizophrenia

Studies	Sample	PM type	Statistics	Effect size
[a]Kondel (2002)	20 chronic schizophrenic patients, no control group	NA	NA	NA
[a]Ritch et al. (2003)	50 schizophrenic patients, no control group	Event-based, time-based	NA	NA
[b]Elvevag et al. (2003)	20 patients with chronic schizophrenia (most were incomplete response to conventional treatments) and 20 controls	Habitual	$F(1,38)=15.67$, $p<0.001$	1.28
[b]Kumar et al. (2005)	42 patients with schizophrenia (30 drug free for at least 3 months and 12 drug naïve) and 42 controls	Event-based	$F(1,82)=22.16$, $p<0.0001$	1.04
[b, c]Shum et al. (2004)	60 chronic schizophrenic patients and 60 controls	Event, time, and activity-based	$F(1,118)=65.61$, $p<0.05$	1.49
[d]Henry et al. (2007)	30 patients with schizophrenia or schizoaffective disorder and 29 controls	Regular Irregular Time-check	Only means and SD available for estimation	1.05 1.44 0.78
[e]Woods et al. (2007)	41 outpatients with schizophrenia and 41 controls	Time Event Summary PM score	$\chi^2=24.48$, $p<0.0001$ $\chi^2=21.09$, $p<0.0001$ $\chi^2=11.78$, $p=0.0006$	1.21 0.83 1.29
Twamley et al. (in press)	72 outpatients with schizophrenia or schizoaffective disorder, no control group	Time Event	NA	NA
[e, f]Wang et al. (in press)	15 schizophrenic patients, 41 individuals with schizotypal personality disorders, and 20 controls	Summary PM score	$F(2,70)=11.71$, $p<0.001$	1.56

NA = not available, PM = prospective memory.
[a] Indicates not enough data to calculate effect size.
[b] Indicates that effect sizes were calculated with F and degree of freedom.
[c] Indicates effect size refers to the overall (three types of) PM performance comparison.
[d] Indicates the effect sizes were calculated by mean and SD.
[e] Indicates that effect sizes were presented in original paper.
[f] Indicates the F value in this study were three group comparisons.

questionnaire (see Methods section for details). Given our previous finding (Wang et al., in press) that non-clinical individuals with schizotypal personality features also showed moderate to severe impairment in prospective memory, and that many studies have demonstrated individuals with schizotypal personality features shared similar cognitive dysfunctions with schizophrenia (e.g., Cadenhead et al., 1999; Mitropoulou et al., 2005), we have included such a non-clinical but supposedly high risk group in this study.

2. Methods

2.1. Participants

Thirty-six patients with schizophrenia who fulfilled the diagnostic criteria of DSM-IV (American Psychiatric Association, 1994) based on diagnostic interviewing (using the Structured Clinical Interview for DSM-IV and medical record reviews) were recruited from three regional psychiatric hospitals in China (Beijing Anding Hospital, the Institute of Mental Health of Shantou University, and the Institute of Mental Health of Peking University). Patients with a history of neurological illness or alcohol/drug dependence (according to clinical records, information from clinician and interview with the patients) were excluded. Clinical symptoms were rated using the Positive and Negative Symptom Scale (PANSS, Kay et al., 1987). Medication side effects were assessed using the Abnormal Involuntary Movement Scale (AIMS, Smith et al. 1979) and Barnes Akathisia Rating Scale (BARS, Barnes, 1989).

Thirty-four college students with schizotypal personality disorder (SPD) were recruited from a large group of 350 students in a number of tertiary institutions in China. These included Peking University, Sun Yat-Sen University, Guangdong Vocational College of Mechanical and Electrical Technology, and Zhongkai University of Agriculture and Technology. The students were screened using the Schizotypal Personality Questionnaire (SPQ) (Raine 1991, adapted Chinese version, Chan et al., submitted for publication—a). According to the scoring criteria suggested by Raine (1991), individuals in the top 10th percentile of the distribution scores were considered as schizotypal. As mentioned in the Introduction, research utilizing high schizotypal individuals can overcome some of the confounds involved in studying actively symptomatic patients. These individuals are non-

psychotic, unmedicated (with antipsychotics) and not hospitalized. Moreover, study of this subgroup may provide important information on the possible cognitive underpinnings of psychotic symptoms.

Twenty-eight healthy controls were also recruited from the above universities. They were also screened using the SPQ (with the low 10th percentile of the distribution scores) and also by a semi-structured interview conducted by a trained research assistant. None of the schizotypal subjects or healthy controls had any family history of psychiatric illness, suffered from a neurological illness or alcohol/drug dependence.

Intellectual functioning was estimated by the short form (information, arithmetic, similarity, and digit span) of the Chinese version of the Wechsler Adult Intelligence Scale—Revised (WAIS-R) (Gong, 1992). The demographic and clinical variables of the participants are shown in Table 2. The present study was approved by the ethics committees of all the corresponding institutes. Written informed consent was obtained from each of the participants.

2.2. Measures

2.2.1. Computer-based prospective memory tasks

The computer-based prospective memory tasks comprised of three subtypes, the event-based, time-based, and activity-based tasks. Details of these tasks have been described in a previous study (Wang et al., in press). In brief, ongoing tasks were divided into semantic and perceptual tasks. In the semantic event-based PM (se_ev) task, a four-character phrase was presented in the center of the screen and the participants were asked to judge whether the phrases were idioms or not. They were asked to press the "J" key to answer affirmatively and to press the "F" key to answer negatively (this was defined as the ongoing task); if there was an animal character in the phrase (e.g., horse), they were asked to press the spacebar (this was defined as the PM task). A total of 5 animal characters appeared during the session and the time interval between the appearances of each animal character was approximately 1 min. The participants were told that the two tasks (the ongoing task and the PM task) were of the same importance.

The semantic time-based PM (se_ti) task was the same as the semantic event-based PM tasks except that a clock was placed at the upper right part of the keyboard (to ensure time monitoring is not confounded by movement agility, the clock was placed in a position such that the participants could see the time clearly without much physical movement of the head), and the participants were asked to monitor the time throughout the experimental session. Each time the clock reached the minute (e.g., 12:23:00, the last two digits are 00), they were asked to press the spacebar. Also, there were no animal characters attached to this task.

Table 2
Demographic and clinical data of patients with schizophrenia, Schizotypal and controls

	Schizophrenia (N=36)		Schizotypal (N=34)		Controls (N=28)		F/χ^2	p
	Mean	SD	Mean	SD	Mean	SD		
Age (years)	31.28	9.08	19.91	0.83	23.93	7.71	24.49	0.0005
Education (years)	12.39	3.02	13.82	0.72	13.79	1.83	5.10	0.008
IQ	102.22	17.42	94.71	15.92	106.57	13.95	4.45	0.014
BDI	10.17	9.19	15.47	9.58	6.64	5.18	8.75	0.0005
DEX	22.50	16.64	34.44	9.23	22.96	9.98	9.58	0.0005
Gender (male: female)	30:6		27:7		9:19		20.21	0.0005
Duration of illness (years)	8.32	8.47						
AIMS	3.58	2.71						
BARS	1.31	1.72						
PANSS positive symptom	14.36	4.87						
PANSS negative symptom	16.00	5.12						
PANSS generalized pathology	30.22	5.79						
PANSS total score	60.58	11.98						
SPQ cognitive-perceptual factor			18.79	4.00	10.04	4.38	67.53	0.0005
SPQ interpersonal factor			18.65	5.13	8.50	4.92	62.38	0.0005
SPQ disorganized factor			10.65	2.90	4.21	2.11	95.67	0.0005
SPQ total score			44.09	7.34	21.11	7.23	152.65	0.0005

Note: The dichotic variable used χ^2 test.
DEX = Dysexecutive Questionnaire, AIMS = Abnormal Involuntary Movement Scale, BARS = Barnes Akathisia Rating Scale, PANSS = Positive and Negative Syndrome Scale, SPQ = Schizotypal Personality Questionnaire.

In the perceptual event-based PM (pe_ev) task, a perceptually degraded digit appeared in the center of the screen and the participants were asked to judge whether or not the digit was 0. The participants were asked to press the "J" key if the digit was 0 and to press the "F" key if the digit was not 0 (i.e., 2, 4, 6, or 8). This was defined as the ongoing task. The digit was between two bars, one above and one below it. If there was a down arrow under the vague digit, the participants were asked to press the spacebar whether the digit was 0 or not. This was defined as the PM task. Five down arrows appeared during the session, and the interval between the appearances of each digit with arrow was approximately 1 min. The participants were told that the two tasks (the ongoing task and the PM task) were of the same importance.

The perceptual time-based PM (pe_ti) task was the same as the pe_ev except that a clock was put at the upper right part of the keyboard and participants were asked to monitor the clock and press the spacebar at each 1 min. The session lasted for about five and a half minutes, and no down arrows appeared in this session.

At the end of each of the above four sessions, participants would see "Thank you for your participation! Bye" on the screen and they were instructed to press the "Enter" key upon seeing this sentence. This was defined as the activity-based PM task. Each time they pressed "Enter", they received a score of one, resulting in a total score of four the total score to index their activity-based PM performance.

2.2.2. Verbal and visual memory

The logical memory and visual reproduction subtests from the Chinese version of the Wechsler Memory Scale—Revised (Gong et al., 1989) were used to measure verbal memory and visual memory. For logical memory, the participant was told a short story and asked to recall it immediately and again 30 min later. For visual reproduction, the participant was shown two pictures (one at a time) for 10 s each, and asked to draw them immediately and again 30 min later.

2.2.3. Executive function

The modified Wisconsin Card Sorting Test (WCST) (Nelson, 1976) was adopted to assess the executive function of the participants, the number of perseverative errors and categories were recorded.

2.3. Subjective measures of prospective memory

The Prospective and Retrospective Memory Questionnaire (PRMQ, Smith et al., 2000) was used to measure subjective complaints of prospective memory. The PRMQ is a 16-item questionnaire. Each participant was asked to rate how often each type of memory failure happened in their daily life on a 5-point scale (very often, quite often, sometimes, rarely, never), resulting in minimum and maximum possible total scores of 16 and 80. Confirmatory factor analysis indicated that the PRMQ consists of a general memory factor together with additional prospective and retrospective memory factors among a group of the general adult population (Crawford et al., 2003). The reliabilities were also acceptable (alpha = 0.8 to 0.989), and demographic variables were not found to influence ratings. Similar latent factor structure was demonstrated in an informant-reported version (Crawford et al., 2006) suggesting that the PRMQ is relatively stable in factor structure and reliability in the general adult population. The Chinese version was used for the current study (Chan et al., 2008; Chan et al., submitted for publication—b). This version has been shown to have the same latent structure as the original version among Chinese participants ($\chi^2 = 163.52$, $df = 88$; RMSEA = 0.074; CFI = 0.942) and with an impressive internal consistency (Cronbach's α ranges from 0.87 to 0.94) and test–retest reliability at 1-month interval (r ranges from 0.7 to 0.73).

Another questionnaire, the Dysexecutive Questionnaire (DEX) (Wilson et al., 1996) was used to assess everyday life cognitive complaints. The DEX asks individuals to rate the frequency of occurrence of certain dysexecutive characteristics, for example, in abstract thinking, impulsivity, confabulation and planning problems. Items included, "I sometimes act without thinking, doing the first thing that comes to mind" and "I am unconcerned about how I should behave in certain situations". This questionnaire has been shown to have good psychometric properties and clinical discrimination (Burgess et al., 1998; Wilson et al., 1996). The Chinese version was used for the current study (Chan, 2001; Chan and Manly, 2002).

Finally, the Chinese version of the Beck Depression Inventory (BDI) (Chan and Tsoi, 1984) was also administered to control for the potential impact of emotional status upon prospective memory and related performance.

2.4. Procedure

The participants were given a general introduction to the study as well as the opportunity to ask questions about the study. They then signed an informed consent form before testing began. IQ subscales were administered to the participants first. Participants completed the questionnaires before the prospective memory computerized tasks. The four PM tasks were given in the following

Table 3
Comparison of prospective memory and other cognitive functions among patients with schizophrenia, schizotypal and controls

	Schizophrenia (N=36)		Schizotypal (N=34)		Control (N=28)		F	p	Sch vs Control	Sch vs Control	Sch vs. SPD
	Mean	SD	Mean	SD	Mean	SD			p	p	p
PM event-based computer test	0.64	0.26	0.68	0.22	0.89	0.12	9.33	0.0005	0.0005	0.008	0.188
PM time-based computer test	0.54	0.34	0.75	0.24	0.85	0.16	15.06	0.0005	0.0005	0.709	0.0005
PM activity-based computer test	0.75	0.34	0.84	0.30	0.96	0.12	4.25	0.017	0.004	0.105	0.259
PM computer test total average	0.64	0.21	0.75	0.14	0.90	0.07	20.62	0.0005	0.0005	0.038	0.0005
Logical memory immediate	10.31	4.01	12.94	3.94	14.86	4.19	10.91	0.0005	0.0005	0.497	0.001
Logical memory delay	8.03	3.95	11.85	4.29	13.18	4.44	15.49	0.0005	0.0005	0.474	0.0005
Visual reproduction immediate	21.39	3.02	23.03	1.57	22.04	2.17	8.11	0.001	0.61	0.004	0.0005
Visual reproduction delay	19.69	4.31	22.79	1.41	21.32	2.28	13.57	0.0005	0.109	0.002	0.0005
WCST perseverative error	5.11	6.44	2.85	3.74	1.68	2.31	6.17	0.003	0.02	0.446	0.001
WCST category	4.47	1.91	4.94	1.71	5.14	1.24	2.85	0.063	0.341	0.216	0.019

WCST = Wisconsin Card Sorting Test. Sch = schizophrenia; SPD = schizotypal.

order: semantic time-based, perceptual event-based, semantic event-based, and perceptual time-based. Finally, participants were interviewed and patients were rated using the PANSS, AIMS, and BARS.

2.5. Data analysis

In view that IQ and emotion might affect cognitive measures (r ranges from 0.072 to 0.424, 0.004 to 0.258, and p ranges from 0.453 to 0.0005 and 0.967 to 0.006, respectively), these two variables were controlled for the subsequent comparison of the cognitive functions among groups. MANCOVA was used to analyze the performance of prospective memory and executive function with IQ and BDI as covariates. For the computer-based tasks, the scores were averaged across the semantic and perceptual conditions to obtain the event-based, time-based, and activity-based computer

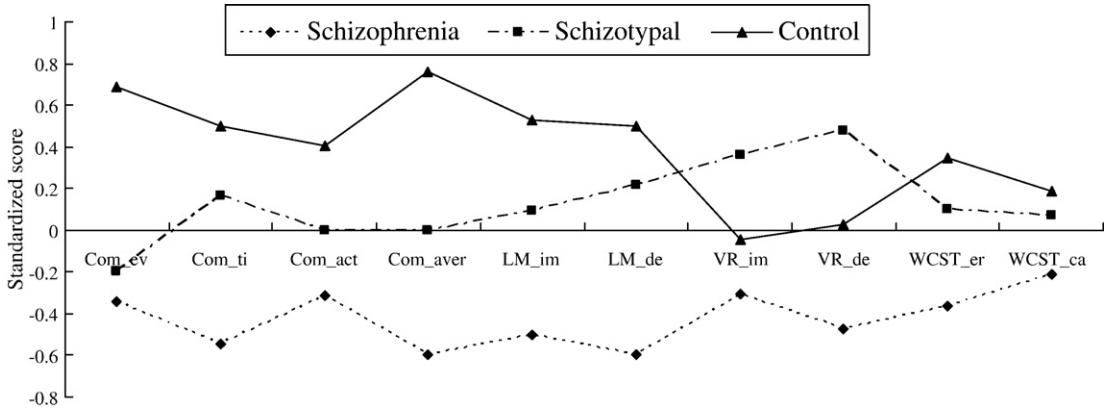

Fig. 1. Cognitive profiles of three groups. Com_ev = computer test of event-based PM, Com_ti = computer test of time-based PM, Com_act = computer test of activity-based PM, Com_aver = average score of all computer PM test, LM_im = Logical memory immediate recall, LM_de = Logical memory delayed recall, VR_im = Visual reproduction immediate recall, VR_de = Visual reproduction delayed recall, WCST_er = Wisconsin Card Sorting Test perseverative error, WCST_ca = Wisconsin Card Sorting Test category. In order for easy understanding, WCST_er was reversed, i.e., higher score means better performance.

Table 4
Repeated measures MANCOVA of prospective memory controlling for IQ and BDI

	Schizophrenia (N=36)		Schizotypal (N=34)		Controls (N=28)		Group	pm_type	Interaction
	Mean	SD	Mean	SD	Mean	SD	$F(df)$; p	$F(df)$; p	$F(df)$; p
Computer test total average score	0.64	0.21	0.75	0.14	0.90	0.07	17.96 (2, 93); <0.001	2.51 (1, 93); 0.116	4.99 (2, 93); 0.009
PM factor score of PRMQ	17.11	6.76	21.24	5.19	17.71	3.29			

PM = prospective memory, PRMQ = Prospective and Retrospective Memory Questionnaire.
The statistical analysis were based on standardized score (only the standardized score would be comparable due to the large difference of raw score in computer test and questionnaire), however, the mean and SD presented the raw score.

test scores. Finally all these scores were averaged to generate a single index for the computer-based PM performance. To compare the subjective rating and objective performances of PM task, prospective memory performances were first transformed into Z scores for both the computer-based tasks (total average PM score) and self-reported data (PM factor score of PRMQ). A 3 (group: schizophrenia, schizotypy, and healthy controls)×2 (type: computer-based PM score vs. questionnaire-based PM score) repeated measure MANCOVA controlling for IQ and BDI was then conducted to examined the main and interactive effects of the IVs on the DVs. Partial correlation analyses were conducted to examine the association between the computer-based and questionnaire-based data controlling for IQ and BDI.

3. Results

Cognitive functions were all statistically significant in group comparisons, for all cognitive functions, $F(18,172)=5.50$, $p<0.001$ (Pillai's Trace), for specific tests see Table 3. Fig. 1 portrays the cognitive profiles of the corresponding cognitive performance of the three groups.

Since we would like to examine the difference between subjective complaints and objective test performances, we performed a repeated measure MANCOVA by taking the PRMQ questionnaire PM factor score and the computer test total average score (all standardized) as a within-subject variable, and group as the between-subject variable. Following the same reasoning as before, IQ and BDI score were included as covariates in this analysis. The findings showed that there was significant main effect for group ($F(2,93)=17.96$, $p<0.001$), main effect of PM type was not significant ($F(1, 93)=2.51$, $p=0.116$), the interaction between group and PM type was significant ($F(2, 93)=4.99$, $p=0.009$) (Table 4). Subsequent independent analyses on the effect of group further showed that there were significant differences among the three groups in the computer-based prospective memory tasks (with p ranges from 0.0005 to 0.038). However,

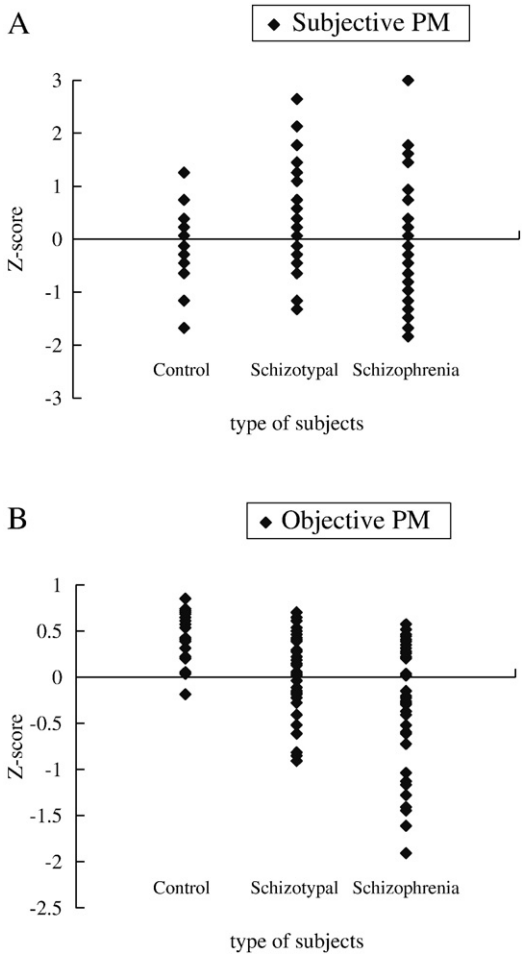

Fig. 2. A. PM complaints in three groups. B. PM performance in three groups. Subjective PM = standardized PM factor score of Prospective and Retrospective Memory Questionnaire. Objective PM = standardized PM computer test total average score.

Table 5
Partial correlations between subjective prospective memory complaints, dysexecutive complaints, and objective cognitive functions

	All participants (N=98)			Schizophrenia (N=36)			Schizotypal (N=34)			Control (N=28)		
	PRMQ_pm	PRMQ_rm	DEX	PRMQ_pm	PRMQ_rm	DEX	PRMQ_pm	PRMQ_rm	DEX	PRMQ_pm	PRMQ_rm	DEX
DEX	0.513 **	0.425 **		0.565 **	0.643 **		0.235	0.053		0.448	0.182	
PM event-based computer test	−0.159	−0.091 *	−0.061	−0.228	−0.051	−0.135	−0.059	0.078	0.155	−0.053	−0.297	0.110
PM time-based computer test	0.019	−0.093	0.082	−0.058	0.233	0.044	−0.063	−0.251	0.089	−0.306	−0.290	−0.238
PM activity-based computer test	0.003	0.058	0.264 *	−0.088	0.042	0.154	−0.083	0.036	0.402	0.486	0.418	0.333
PM computer test total average	−0.056	−0.106	0.164	−0.173	0.125	0.070	−0.125	−0.082	0.419	0.013	−0.156	0.073
logical memory immediate	0.178	0.023	0.185	0.294	0.344	0.464 *	0.257	0.017	−0.065	−0.232	−0.078	−0.106
logical memory delay	0.160	−0.086	0.154	0.180	0.032	0.105	0.218	−0.023	0.041	−0.242	−0.168	0.027
visual reproduction immediate	0.144	0.004	0.050	0.192	0.017	0.079	−0.086	0.035	−0.031	−0.100	0.034	−0.113
visual reproduction delay	0.090	−0.027	0.076	0.042	−0.008	0.080	0.164	0.206	−0.145	−0.319	−0.132	−0.087
WCST perseverative error	0.103	0.085	0.093	0.299	0.091	0.367	0.113	0.108	0.025	−0.002	0.054	−0.214
WCST category	−0.012	−0.104	−0.052	−0.154	−0.114	−0.368	−0.011	−0.089	0.122	0.098	−0.271	0.145

DEX = Dysexecutive Questionnaire.
PRMQ_pm = PRMQ prospective factor score.
PRMQ_RM = PRMQ retrospective factor score.
* Indicates significant at 0.05 level after Bonferroni adjustment.
** Indicates significant at 0.01 level after Bonferroni adjustment.

only significant difference found between the schizotypal and schizophrenia group was the standardized score of the subjective prospective memory score (p=0.014). Fig. 2 shows the corresponding memory performances of the three groups.

A check on the partial correlation (controlling for BDI and IQ) between the PRMQ prospective memory and retrospective memory factor scores, DEX score, and objective cognitive function performance indicates that significant correlations were found between the subjective complaints (i.e., PRMQ and DEX), but not between other objective measures and the subjective complaints. This pattern persisted in either the whole group (schizophrenia, SPD, and healthy controls) or in separate groups (Table 5).

4. Discussion

The major findings of the current study are summarized as follows:

1. There was a main effect of group condition in the memory functions. In particular, patients with schizophrenia demonstrated significantly poorer performance in all domains of memory function except visual memory compared to healthy controls and individuals with SPD.
2. There was a significant interaction effect of prospective memory type and group condition. Although patients with schizophrenia demonstrated the worst computer-based measures of prospective memory, they did not report significantly disproportionate higher subjective complaints than controls. For individuals with SPD, their performance on computer-based prospective memory tasks was significantly better than those of schizophrenia patients but poorer than controls. However, their subjective complaints of prospective memory deficits tended to be higher than patients with schizophrenia and controls.
3. The subjective complaint of prospective memory problems was significantly associated with self-reported executive dysfunction, but not with computer-based tests of prospective memory and other objective measures of memory. These patterns were consistent across patients with schizophrenia, individuals with SPD, and healthy controls.

Schizophrenia was shown to be associated with deficits in all three subtypes of prospective memory, consistent with previous research (Elvevag et al., 2003; Henry et al., 2007; Kumar et al., 2005; Shum et al., 2004; Wang et al., in press; Woods et al., 2007). A prospective

memory deficit was also found in a non-clinical, but high risk group of individuals prone to psychosis, although this deficit was limited to the event-based subtype. This is consistent with our previous finding that individuals with schizotypal personality features demonstrate impaired event-based prospective memory performance on both semantic and perceptual tasks as compared to healthy controls (Wang et al., in press).

The interaction effect of prospective memory type and group condition is noteworthy. Woods et al. (2007) found no interaction between group status and prospective memory task subtypes, whereas Shum et al. (2004) showed an interaction effect, with time-based performance significantly more impaired than event-based performance. These studies, however, were limited to using computer-based or laboratory-based paradigms. This study compared computer-based performance to prospective memory complaints in everyday life for both patients with schizophrenia and individuals with SPD. Interestingly, patients displayed worse computer-based performance than prospective memory complaints in everyday life, whereas the SPD group displayed the reverse pattern. This could be due to several factors.

First, schizophrenia is associated with poor insight, that is, a lack of awareness of one's own illness and symptoms (Amador et al., 1991; David, 1990). Patients with schizophrenia usually provide poor estimations of their own cognitive deficits and functional capacities. Individuals with SPD, on the other hand, may not exhibit this lack of awareness, and hence may be able to report their problems more accurately. A check on the item that assesses insight in the PANSS indicates that most of the patients in the current study did not show a rating of 3 or higher (i.e., moderate impairment). Although insight is a multifactorial construct and may differ between domains of function, these preliminary findings suggest the discrepancy between objective and subjective measures of prospective memory in patients is unlikely due to insight impairment. There are two awareness measures within the cognitive domain which may be differentially impaired; the self-report prospective memory questionnaire and the DEX. Although questionnaires such as the PRMQ and DEX are used to measure cognitive functions, they are also designed to capture some of the broader neurobehavioral changes that are likely to occur with a compromise of functioning, such as a loss of insight (Bogod et al., 2003; Chan and Bode, 2008; Crawford et al., 2006). A more rigorous experimental design utilizing a multidimensional scale of insight such as the Amador Insight Scale (Amador et al., 1991) and the administration of both self- and informant-reported prospective memory and dysexecutive function measures should be conducted in order to establish the relative contribution of insight compared to other cognitive processes.

Second, highly constrained laboratory environments and naturalistic real-life scenarios are inherently different (Sbordone, 1996). Complex, multi-step tasks in unstructured environments or everyday life scenarios may require a more complicated series of responses, including triggering of PM to initiate sub-tasks when conditions are optimal, and inhibition of irrelevant and inappropriate actions to different sub-tasks (Chan and Chen, 2005). While the experimental approach and laboratory tasks can reflect the underlying cognitive mechanisms of prospective memory in patients with schizophrenia, the ecological approach of using self-report data or other tests simulating everyday life scenarios should reflect the naturalistic difficulties these patients encounter in everyday life, and therefore provide a better reflection of their social functioning (Evans et al., 1997; Henry et al., 2007).

Third, empirical findings on the relationship between subjective and objective measures of cognitive performance suggest a relatively weak association in healthy volunteers (e.g., Broadbent et al., 1982; Hermann, 1982; Martin and Jones, 1983) and schizophrenia patients (e.g., Prouteau et al., 2004; Stip et al., 2003). For example, Stip et al. (2003) failed to find a relationship between subjective and objective memory in schizophrenia. Rather, no relationship between subjective cognitive domains (including attention, memory and executive function) and the appropriate objective cognitive domains was found. Our findings also show a non-significant relationship between computer-based prospective memory performance and subjective complaints. In contrast, a modest to large association was found between the subjective prospective memory complaints and the executive function complaints in patients with schizophrenia. Taken together, these suggest that the lack of correspondence between subjective cognitive domains and objective cognitive tests in general, and prospective memory in particular, is associated with the questionable segregation of cognitive functioning into succinct domains.

The current study has a number of limitations. As outlined above, only one item from the PANSS was used to assess insight impairment. As insight is a multifactorial construct and can differ between domains of functions, future studies should incorporate assessment specifically capturing this type of impairment. Similarly, the target sample should be extended to include the significant others of the patients in order to obtain a better picture of the everyday prospective memory

performance of the patients. The current findings may be biased to patients receiving antipsychotic medication. Given the effects of medication upon neurocognitive function, particularly on memory functioning, the generalizability of the current findings to first-onset medication-naïve patients remains unclear and warrants further investigation. Given that there are very few, if any, studies examining this issue, the underlying relationship between awareness of prospective memory impairment in schizotypy and schizophrenia is unknown. Therefore, studying insight impairment in individuals with schizotypal personality features may be a potential research direction. The finding that individuals with schizophrenia did not report prospective memory problems has implications for management and treatment. For example, if a patient with schizophrenia does not realise he or she has a prospective memory problem, he or she will not pay attention to these problems in everyday life (this can be dangerous) and will not be motivated to seek treatment. In conclusion, the current study adds further knowledge to the research of prospective memory performance in schizophrenia, and supports the claim that subjective and objective measures of this function are two distinct domains that need to be investigated further. Future research is also needed to examine how prospective memory deficits affect social functioning in this clinical group.

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Contributors

Raymond Chan and Ya Wang designed the study, analyzed the data, and wrote up the first draft of the paper; Ya Wang administered the neuropsychological tests and questionnaires to the participants; Zheng Ma, Xiao-hong Hong, Yanbo Yuan, Zhanjiang Li and Xin Yu performed clinical interview and rating on patients; David Shum contributed to the design of the research paradigms and was involved in improving the draft of the paper; Q Gong was the last reader of the paper and gave suggestions for the improvement of the text. All authors contribute to and have approved the final text.

Conflict of interest

None.

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