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ORIGINAL REPORT

A RANDOMIZED CONTROLLED TRIAL OF PROSPECTIVE MEMORY REHABILITATION IN ADULTS WITH TRAUMATIC BRAIN INJURY

David Shum, PhD[1], Jennifer Fleming, PhD[2,3,4], Hannah Gill, M Occ Thy St[2], Matthew J. Gullo, PhD[1] and Jenny Strong, PhD[2]

From the [1]School of Psychology and Griffith Health Institute, Griffith University, [2]The University of Queensland, School of Health and Rehabilitation Sciences, [3]Occupational Therapy Department, Princess Alexandra Hospital, and [4]Centre for Functioning and Health Research, Metro South Health District, Queensland Health, Brisbane, Australia

Objective: **To examine the efficacy of compensatory prospective memory training, preceded by self-awareness training for adults with traumatic brain injury.**

Design: **Randomized controlled trial with 4 intervention groups: (*i*) self-awareness plus compensatory prospective memory training; (*ii*) self-awareness training plus active control; (*iii*) active control plus compensatory prospective memory training; and (*iv*) active control only.**

Subjects: **Forty-five rehabilitation patients with moderate–severe traumatic brain injury living in the community.**

Methods: **Four groups of participants completed an 8-session individual intervention programme with pre- and post-assessment by a blind assessor on a standardized test of prospective memory, actual strategy use, relatives' ratings of prospective memory failure, and level of psychosocial re-integration.**

Results: **Larger changes in prospective memory test score and strategy use were found in groups with compensatory prospective memory training compared with those groups without.**

Conclusion: **The results provide evidence that prospective memory can be improved in patients with traumatic brain injury using a compensatory approach in a relatively short duration and low intensity intervention.**

Key words: brain injuries; memory; rehabilitation; awareness.

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Correspondence address: David Shum, School of Psychology, Mt Gravatt campus, Griffith University, 176 Messines Ridge Road, QLD 4122 Brisbane, Australia. E-mail: D.Shum@griffith.edu.au

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INTRODUCTION

Prospective memory (PM), also known as memory for intentions, refers to the ability to remember to perform an intended action at a future point in time (1). Examples of PM include remembering to post a letter when one passes a post office or remembering to attend an appointment. While the former is called event-based PM because the retrieval of the intended action is triggered by an external cue, the latter is called time-based PM because the intended action is cued by a specific time (2). PM is a relatively new construct, in contrast to retrospective memory (RM), which involves recall of previously learned information or past events. Although failures of PM are inevitable from time to time for all individuals, repeated failure of PM is associated with factors such as ageing, dementia, schizophrenia, and brain injury. Frequent PM failure is frustrating for carers, may compromise a person's ability to live independently and safely, and may cause difficulty with maintaining employment and social relationships (3). At best, lapses of PM cause embarrassment and inconvenience; at worst they can be life-threatening.

A body of research has consistently identified that PM failure is more common among individuals with traumatic brain injury (TBI) than non-injured controls (4–8). TBI often involves damage to the prefrontal cortex (9), which is associated with executive functions (10). Prospective remembering involves a range of executive processes, such as planning, disruption of an ongoing activity, initiation of an action, and strategy use (11). It is not surprising, therefore, that executive dysfunction has been shown to predict PM impairment in individuals with TBI (12–14).

Intervention to improve memory function is an important part of rehabilitation following TBI, both because of the functional consequences for independence and community reintegration, and because memory problems are one of the most common complaints of people with brain injury (15). Traditionally, memory rehabilitation has concentrated on improving RM, with approaches that can be categorized as remedial or compensatory. Remedial or "bottom up" approaches emphasize restoring memory functions, usually via repetitive drills or training activities designed to stimulate damaged neural networks or establish new networks (e.g. using repeated practices to learn computer operations or programming) (16). Compensatory or "top down" approaches concentrate on the use of strategies, environmental modifications, and intact cognitive functions to maximize functional performance (15). "Bottom up" approaches aim to restore lost functions, whereas "top down" approaches draw on intact cognitive skills to apply compensatory strategies, such as the use of notes and environmental cues to improve functional performance. The rehabilitation of

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PM can also be categorized according to whether a remedial or compensatory approach is used (11).

It is generally recognized that remedial memory training programmes are not particularly effective for people with brain injury, mostly because of the task-specific nature of any improvements during training and the failure to generalize gains made during training to functional activities in everyday life (11). Although Sohlberg et al. (17, 18) and Raskin & Sohlberg (19) reported positive effects for a remedial approach they developed for PM in case studies, the training programme required substantial commitments of time and effort, for example 4–6 h per week over several months (17). It is also not clear to what extent gains generalized beyond the ability to perform the simple, non-goal directed activities required in training.

Few studies have specifically investigated compensatory approaches to PM rehabilitation, despite the fact that the use of compensatory strategies is commonplace in most brain injury rehabilitation settings. Practical strategies include environmental modifications (e.g. notices, Post-it notes, labelled shelves, and structured work environments), organizational devices (e.g. electronic diaries, memory notebooks, and computers), and external cues (e.g. alarms, buzzers, calendars, and pagers). Research with small TBI samples (e.g. 20, 21) and case studies (e.g. 22) has described the use of electronic devices (palmtop computer, Voice Organiser, and paging system) to compensate for PM deficits. Fish et al. (23) evaluated the use of a "content-free" cue in the form of a text message to remind 20 people with brain injury to monitor behaviour and found an improvement on cued days compared with days on which the cue was not used. Several formal training approaches to make use of a memory notebook have been devised for TBI rehabilitation (24, 25, 26) and some have been shown to be effective with relatively small samples of up to 20 participants (e.g. 27). Further controlled studies with larger samples are needed to investigate the effectiveness of compensatory strategies in ameliorating the effects of PM impairment following TBI, and to determine whether strategy use is generalized to everyday life.

A key factor in achieving generalization is the individual's self-awareness of the extent of his or her memory impairment and the need to employ strategies to compensate for it (28). Self-awareness, however, is a higher level cognitive function also associated with the prefrontal cortex (10), and one that is frequently diminished following TBI. Studies have shown that individuals with TBI tend to overestimate their PM abilities (6). It would follow, therefore, that compensatory rehabilitation approaches may be enhanced if preceded by self-awareness training to improve the individual's awareness of PM deficits. Our early research (3) described a PM rehabilitation programme that incorporated both a self-awareness training component and a compensatory approach, and found promising results. The current study used a randomized controlled design systematically to evaluate the efficacy of compensatory PM training preceded by self-awareness training for adults with TBI. Specifically, the study aimed to evaluate the effects of self-awareness training and compensatory training on PM as assessed by neuropsychological test scores, participants' reports of strategy use, and relatives' ratings of PM failure and level of psychosocial reintegration. Four memory rehabilitation programmes were compared: (*i*) self-awareness plus compensatory PM training; (*ii*) self-awareness training plus active control; (*iii*) active control plus compensatory PM training; and (*iv*) active control only. The active control for self-awareness training involved a programme that was designed to be personally engaging and informative but did not involve reference to PM or self-awareness. The active control for compensatory PM training involved a remedial training programme that, because of its limited duration, was not expected to have any substantial effect on PM.

It was hypothesized that the magnitude of change in all 4 dependent variables following intervention would differ significantly among the 4 groups, being significantly greater for those receiving compensatory training than for those not receiving such training and significantly greater for those receiving self-awareness training than for those not receiving such training. Given the finding of our earlier case study it was of interest whether the combination of compensatory training and self-awareness training would produce the largest change.

METHODS

Design

This randomized controlled trial involved a 2×2 design, with 2 between-subjects variables: self-awareness training and compensatory PM training. Each variable had 2 levels (self-awareness vs active control and compensatory training vs active control). Participants were randomly assigned to 1 of the 4 resulting groups. Participants were assessed on a range of measures at pre- and post-intervention to compare the relative efficacy of compensatory PM and self-awareness training. The original plan for the study had the between-subjects variables included with the pre- and post-intervention time points as a within-subjects variable in a $2 \times 2 \times 2$ mixed analysis of variance. It was estimated that for the two-way interaction effect (group × time) and with alpha of 0.05, a medium effect size of $f=0.25$ would be estimated with power of 0.80, if a sample size of $n=12$ for each cell in the design was obtained. Subsequently, it was decided to employ a non-parametric form of analysis, for which this power estimate is not appropriate and for which power cannot be readily determined.

Participants

Forty-five participants were recruited from 418 community-dwelling patients with TBI consecutively discharged from the Princess Alexandra Hospital Brain Injury Rehabilitation Unit or admitted as outpatients during the accession period of January 2004 through December 2006.

Patients were required to meet the following criteria for inclusion in the study: (*i*) diagnosis of moderate or severe TBI, manifested by Glasgow Coma Scale (GCS) score at the scene (or earliest recorded score) of 13 or less, or post-traumatic amnesia (PTA) of 24 h or more, or cerebral contusion or haemorrhage on either computed tomography (CT) or magnetic resonance imaging (MRI); (*ii*) aged between 18 and 60 years; (*iii*) able to communicate in English; (*iv*) ambulant or independently mobile in manual or electric wheelchair; (*v*) with a significant other available to participate in the study; (*vi*) no prior head injury or hypoxic injury; (*vii*) gives informed consent.

At screening 313 of the 418 patients did not meet these inclusion criteria. Of the 105 eligible patients, 23 did not consent to participate

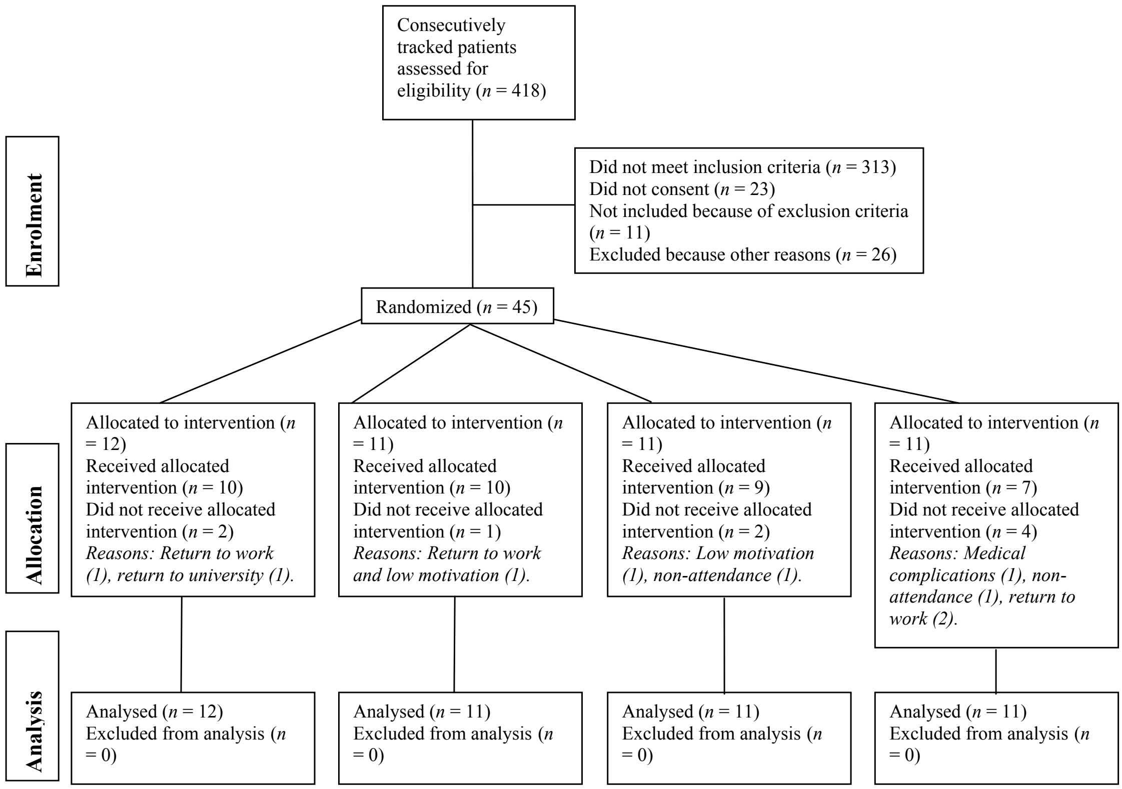

Fig. 1. Randomized control trial flow-chart and allocation of participants into intervention groups.

(Fig. 1). The 23 eligible patients who did not consent were similar to study participants in demographics, injury severity, and recovery stage. Inpatients were consented prior to discharge home, and then re-contacted after a 1-month period of adjustment in the community before commencing participation in this study. At this point, consenting patients were excluded from the study if they had severe behavioural problems that would compromise engagement in community-based rehabilitation, experienced low-level arousal, or had severe amnesia. Likewise, patients with significant communication deficits, for example, dysphasia, or significant visual impairment preventing diary use, a significant diagnosed pre-morbid psychiatric and/or neurological disorder, were also excluded. Exclusion from the study was determined by consultation with a treating clinician from the rehabilitation team. Using the above criteria, a total of 11 patients were excluded for the following reasons: psychiatric or behavioural problems (3), communication difficulties (3), no available/consenting significant others (5). A further 26 patients were not allocated to a treatment group when contacted because of other reasons, including relocation following discharge (6), travel no longer being feasible due to distance (4), return to work (6), medical complications (2), repeated non-attendance at pre-assessment (6), and re-consideration (2). The remaining 45 patients were randomly allocated to the 4 treatment groups.

The 45 patients comprised 37 males (82.2%) and 8 females (17.8%), aged between 19 and 57 years (median 25.00, 25th and 75th quartiles 21.00 and 34.50, respectively). All participants had sustained moderate to severe TBI, with number of days in PTA ranging from 2 to 152 (median 35.00, 25th and 75th quartiles 22.00 and 72.00, respectively). The median GCS at the scene of injury or earliest recorded score was 6.00 (25th and 75th quartiles 3.75 and 9.00, respectively). Mean time since injury was 273 days (25th and 75th quartiles 179.50 and 417.50, respectively). Motor vehicle accidents (40.0%) were the most frequent cause of injury, followed by motorcycle accidents (15.6%), falls (13.3%), bicycle accidents (11.1%), assault (6.7%), pedestrians having been hit by a motor vehicle (4.4%), and sporting accidents (4.4%). Two participants (4.4%) reported sustaining their injury through "other" means.

The majority (86.7%) of participants were of Caucasian background, 6.7% identified themselves as Asian, 2.2% as Aboriginal or Torres Strait Islander, 2.2% as Pacific Islander, and 2.2% as African. Prior to their injury, participants' occupations included students (22.2%); clerical workers, sales and service workers (22.2%); tradespersons (17.8%); labourers (11.1%); professionals (6.7%); retired, homemakers, not working or receiving a pension (8.9%); associate professionals (4.4%); production and transport workers (4.4%); and managers and administrators (2.2%). Total years of education ranged from 6 to 17 years, with a median of 12.00 years (25th and 75th quartiles 10.00 and 13.00, respectively). Median level of intelligence estimated with the Vocabulary and Matrix Reasoning subtests of the Wechsler Abbreviated Scale of Intelligence (WASI; 29) was 106.00 (25th and 75th quartiles 94.50 and 111.50, respectively). All 45 participants were considered by their rehabilitation team to have difficulties with PM and they had a median score on a psychometric PM test (see below) that fell in the poor range of performance.

Measures

Participants' PM was assessed by one of two psychologist interns blind to group membership using a combination of: (*i*) psychometric testing; (*ii*) objective measures of strategy use; (*iii*) significant others' ratings of PM failure in everyday life at pre- and post- intervention assessments. Their level of psychosocial reintegration was assessed using significant others' ratings.

The psychometric test employed was the Cambridge Prospective Memory Test (CAMPROMPT), which was developed to measure time- and event-based PM performance (30). The participant is required to perform 3 time-based tasks and 3 event-based tasks while performing some ongoing activities. Spontaneous use of strategies such as note-taking is allowed. An alternative form (Version B) was used at the post-intervention assessment. Total CAMPROMPT scores are out of 36, with higher scores reflecting better PM performance.

A count of diary entries relevant to PM tasks was used to obtain an objective measure of participants' strategy use in everyday life. Participants were given a diary for a 4-week baseline period prior to the intervention with instructions to record in the diary any tasks they wanted to remember to do. Following the baseline period, the number of valid diary entries relating to PM tasks was recorded each week, and averaged over the 4-week period to provide a measure of strategy use. At post-intervention assessment the number of valid diary entries per week from pre-intervention assessment (approximately 8 weeks) was calculated.

PM performance was further assessed using the Comprehensive Assessment of Prospective Memory (CAPM). Section A of this questionnaire assesses the frequency of everyday PM lapses and can be administered to the person being assessed (self-report) or to a significant other (31). Frequency of PM failure on the 39 items of the instrument are rated on a 5-point scale, where 1 = "never" and 5 = "very often". Items can also be scored as "not-applicable". Mean responses were calculated by adding the item responses together and then dividing by the total number of items excluding any "not applicable" items. Significant-other ratings have been demonstrated to have greater concurrent and convergent validity than self-ratings (32), and were therefore used in the current study.

The effect of intervention on the level of psychosocial reintegration was assessed using significant others' ratings on the Sydney Psychosocial Reintegration Scale (SPRS; 33). The SPRS is a reliable and valid means of measuring 3 broad domains (Occupational Activities, Interpersonal Relationships, and Independent Living Skills) by comparing current level of function with pre-morbid function. Total SPRS score ranges from 0 to 72, with higher scores indicating better psychosocial functioning.

Procedure

The study was approved by the Griffith University Human Research Ethics Committee, University of Queensland Behavioural and Social Sciences Ethical Review Committee, and Princess Alexandra Human Research Ethics Committee and was carried out in accordance with the National Health and Medical Research Guidelines. The trial was registered with the Australia New Zealand Clinical Trials Registry (registration number 12605000754640). Eligible patients as well as significant others provided written informed consent. Participants were posted a diary to use during the 4-week baseline period. The number of valid diary entries (per week) was recorded during a pre-intervention assessment, at which time the CAMPROMPT and other neuropsychological tests were administered by a psychologist intern. Significant others completed the CAPM and SPRS during this time.

Participants who had completed pre-assessment were then assigned to 1 of 4 treatment groups using restricted randomization with blocking. Allocation was concealed through the selection of one-sided numbered cards, by a researcher blind to assessment results, such that no group would have $n+1$ participants until all other groups had n. This allowed for relatively balanced group sizes. All interventions involved 8 weekly attendances at an individual therapy session at a university clinic, with each session lasting approximately 1.5 h. Each of the 4 intervention programmes was administered by a trained researcher according to standardized, written week-by-week procedures. Programmes comprised 2 weeks' self-awareness training or active control plus 6 weeks' compensatory PM training or active control. The researcher implementing intervention was a qualified occupational therapist blind to participants' pre-assessment results. The 4 outcome measures were repeated at a post-intervention assessment by a psychologist intern who was blind to group allocation. Components of the rehabilitation programmes were as follows.

Self-awareness training. Self-awareness training aimed to facilitate improved insight into PM problems and their impact on everyday functioning (3). Training focused on developing therapeutic rapport with the participant, introducing the concept of PM, educating the participant about the cognitive functions involved in PM, and the impact of TBI on PM ability. The sessions incorporated PM tasks (time-based, event-based, and activity-based) and self-prediction plus monitoring of PM performance on these various tasks. The objective was to encourage development of self-awareness of PM dysfunction and the importance of compensatory strategies through self-assessment and the analysis of peers (others with TBI interviewed on video about their PM failures). Participants were prompted to discuss the video clips (e.g. What sort of things do they forget to do? What do they do to help remember to do things? Do you forget the same sorts of things?). Participants also monitored their PM performance using "memory lapse" records during the week at home.

Active control for self-awareness training. This aimed to develop a comparable level of rapport between the therapist and participant, while being unrelated to self-awareness or PM. It involved engagement of the participant in one-to-one therapy, discussion of his/her experiences, development of a timeline of meaningful life events, and discussion of memories involving important people in the participant's life, as well as administration of the Autobiographical Memory Interview (AMI) (34), which assesses retrospective recall of life events. Education about attention, concentration, and brain function was included through use of documentary material and models of the human brain.

Compensatory PM training. This rehabilitation approach involved training in strategies to compensate for PM problems in daily life, as described previously (3). It aimed to maximize use of a diary or organizational device and time management within participants' existing daily and weekly routines to minimize PM failure. Participants were taught steps for writing reminders, appointments, and note-taking, and encouraged to identify individual cuing mechanisms for routine diary review, throughout each day, leading to habitual diary use. This involved the use of standardized simulation scenarios that allowed participants to practice strategy use, and transfer skills to their daily lives. Simulations were used instead of personalized, "real life" examples to prevent artificial inflation of participant diary entries by virtue of therapist prompting. Training involved family or friends in understanding participants' compensatory strategies to help reinforce and assist with generalization of skills beyond the training environment. Use of routines and weekly planners were taught along with time management techniques such as prioritization of tasks. Participants were trained to recognize new skills, and brainstorm applications and benefits of compensatory strategies in everyday life to encourage ongoing strategy use following completion of the programme. Scenarios were incorporated to consolidate learned strategies and encourage their application in different situations.

The key objectives of the 6 sessions were: (*i*) participant to become aware of the diary/organizer's structure and uses, and identify an individualized cuing mechanism for routine checking of the diary/organizer; (*ii*) participant to use a diary/organizer that meets individual preferences for type/style, and to demonstrate basic note-taking skills for writing reminders; (*iii*) to involve family and friends in the participant's diary/organizer training; (*iv*) to maximize organization and time management within the participant's existing daily and weekly routines to minimize PM failure; (*v*) to reinforce diary/organizer use and note-taking skills, recognize new organizational skills and their usefulness, and critique everyday situations involving PM; (*vi*) to monitor effectiveness, and reinforce ongoing diary/organizer use and note-taking skills, and provide closure to the training programme.

Active control for compensatory PM training. To provide a stringent active control for compensatory PM rehabilitation, a remedial training approach was adopted for the 6 sessions of PM rehabilitation. It was anticipated that the use of remedial training for this period of time would show negligible treatment effect on underlying PM dysfunction. The techniques utilized in the study were based on an approach described by Raskin & Solhberg (19) with some minor variations to their original method with regard to feedback and scoring. The training consisted of a procedure to establish the participant's existing level of PM ability and to train him/her to lengthen the duration over which he/she could prospectively remember by gradually increasing the time lapse to recall of both event-based and time-based tasks during performance of an ongoing task. Ongoing filler tasks included a variety of pen-and-paper worksheets designed for use with individuals with brain injuries, addressing information/visual processing and attention (e.g. maths, copying, and cancellation). Filler tasks were presented in the same order for each participant from a workbook.

Existing PM ability was first ascertained by the time delay for which the participant could successfully remember to perform intended tasks; that is, they accurately responded to 3 out of 4 trials. The trainer assigned PM tasks at this training start level until the participant gave accurate responses to 5 consecutive trials. The time delay was then increased by 1 min, and the same procedure utilized at that level. Tasks alternated between time- and event-based cues between trials. A digital clock display was used for time-based tasks. Event cues included a combination of motor and verbal actions performed by the trainer. A combination of motor and verbal PM tasks was given to each participant in the same order from a list of tasks (20 each). Motor tasks included demonstrated instructions, for example "Raise your arm like this" and verbal tasks were demonstrated questions or statements, such as "Ask me: 'What is your name?'". Participants were asked to copy the demonstrated task and then told when it should be performed (i.e. in a certain number of min or time-based tasks or response to a specific cue for event-based tasks). If the participant performed an incorrect task or at an incorrect time, the trainer gave opportunity for him/her to recall/perform the correct task/time/event. Prompts were provided for missed PM tasks.

Statistical analyses

An alpha level of 0.05 was used for all statistical tests. Effects of the intervention were assessed by computing change scores (post- minus pre-intervention score) for each of the dependent variables. Confidence intervals (95% CI) for the median change scores for the 4 dependent variables were determined by re-sampling using Microsoft Excel. Sample size was the *n* of the group for which CIs were being computed and 1000 samples with replacement were used to calculate the 95th percentile confidence limits. Missing data due to drop out at post-intervention was handled by assuming that the intervention had no effect and that the participant was at his or her pre-intervention level (i.e. change score was zero). Statistical comparisons among the groups on change scores and pre-intervention levels used the Kruskal-Wallis test. Where a significant overall effect was found, Mann-Whitney *U* tests were used to compare collapsed groups to evaluate difference in change score for each treatment component (viz. compensatory PM and self-awareness training) separately. Statistical comparisons involving frequencies used the McNemar test and correlations used the Spearman rho.

RESULTS

Preliminary comparisons among the 4 groups were conducted to test for differences on gender, age, time since injury, length of PTA, initial GCS, and IQ. As shown in Table I, there were no statistically significant differences on these variables, although median time since injury and length of PTA varied considerably among groups.

CAMPROMPT (total score and note-taking)

The pre-intervention score and change score on CAMPROMPT for the 4 groups of participants are shown in Table II. Results of statistical comparison of the groups indicated that they were not significantly different on the pre-intervention scores but were significantly different on the change scores. Follow-up analyses indicated that the groups with a self-awareness training component were not significantly different from those without on the change scores ($p=0.313$), but the groups with a compensatory training component were found to have a significantly larger change scores than those without ($p=0.007$). Among the 4 groups of participants, the group that received self-awareness and compensatory PM training did not have the largest change score on the CAMPROMPT.

In undertaking the CAMPROMPT, participants were allowed to take notes but were not led to do so. At pre-intervention, spontaneous note-taking was found to correlate significantly with the total score of the CAMPROMPT, $r=0.361$, $n=45$, $p=0.002$. The number of participants in the 4 groups who took notes before and after intervention is shown in Table III.

There was a significant increase in the number of participants who took notes ($p=0.008$) following compensatory training, but not for those without this component ($p=0.480$). This increase also correlated with the change in CAMPROMPT total score from pre- to post-assessment, $r\ (43)=0.533$, $p=0.0005$. For groups with a self-awareness training component, there was no significant increase in the number of participants who took notes ($p=0.074$) but a significant increase was found for those without such a component ($p=0.041$).

Number of valid diary entries

Pre-intervention and changes scores for the number of valid diary entries per week for the 4 groups of participants are shown in Table II. Pre-intervention scores were not significantly different among the 4 groups but there was a significant difference for change scores. The groups with a self-awareness training component were not found to be significantly different from groups without on the change scores ($p=0.205$), but the groups with a compensatory training component were found

Table I. *Descriptive statistics (median and 25th; 75th quartiles) for each experimental group on selected background characteristics and results of statistical comparison (χ^2)*

Characteristic	S-A plus Compensatory training	Active control plus Compensatory training	S-A training plus Active control	Active control	χ^2 (df)	*p*
Gender	11 M/1 F	8 M/3 F	9 M/2 F	9 M/2 F	1.413 (3)	0.702
Age	23.50 (21.25; 33.00)	33.00 (21.00; 48.00)	23.00 (21.00; 45.00)	24.00 (20.00; 29.00)	1.935 (3)	0.586
Time since injury (days)	348.00 (187.25; 544.75)	209.00 (184.00; 333.00)	368.00 (273.00; 994.00)	194.00 (172.00; 294.00)	6.880 (3)	0.076
Length of PTA (days)	50.50 (30.25; 72.75)	35.00 (24.75; 81.75)	41.00 (15.00; 91.50)	29.50 (13.00; 39.00)	3.100 (3)	0.376
Initial GCS	4.00 (3.25; 8.50)	7.00 (3.00; 8.00)	6.00 (4.50; 13.00)	8.00 (3.50; 13.00)	0.924 (3)	0.820
WASI IQ	103.00 (90.25; 111.75)	106.00 (92.00; 118.00)	103.00 (93.00; 111.00)	109.00 (98.00; 118.00)	1.465 (3)	0.690

S-A: self-awareness; PTA: post-traumatic amnesia; GCS: Glasgow Coma Scale; WASI: Wechsler Abbreviated Scale of Intelligence; df: degrees of freedom.

Table II. *Descriptive statistics (median and 25th; 75th quartiles) for each experimental group on pre-intervention and change scores for 4 dependent variables and results of statistical comparison (Kruskal-Wallis)*

Measure	S-A plus compensatory training	Active control plus Compensatory training	S-A training plus Active control	Active control	χ^2 (df)	*p*
CAMPROMPT						
Pre-inter	26.50 (19.50; 28.75)	22.00 (16.00; 32.00)	23.00 (17.00; 30.00)	28.00 (18.00; 30.00)	0.974 (3)	0.808
Change	3.50 (0.25; 9.75)	9.00 (0.00; 10.00)	–1.00 (–3.00; 6.00)	0.00 (0.00; 4.00)	8.692 (3)	0.034
95% CI	1.00 to 9.00	0.00 to 10.00	–2.00 to 0.00	0.00 to 1.00		
Average number of valid diary entries (per week)						
Pre-inter	7.00 (2.25; 9.75)	8.00 (8.00; 9.50)	1.75 (0.75; 9.00)	2.50 (1.60; 7.00)	2.265(3)	0.519
Change	1.50 (–1.13; 4.00)	3.10 (3.10; 14.18)	–0.75 (–1.25; 3.25)	0.00 (–0.30; 1.68)	8.511 (3)	0.037
95% CI	–1.13 to 2.94	0.00 to 14.18	–1.25 to 0.00	–0.30 to 0.00		
CAPM (Relative Form)						
Pre-inter	2.03 (1.74; 2.48)	2.15 (1.30; 2.85)	1.30 (1.13; 2.85)	1.85 (1.40; 2.48)	1.581 (3)	0.664
Change	–0.15 (–0.48; 0.00)	0.00 (–0.55; 0.00)	0.00 (–0.15; 0.03)	0.00 (–0.27; 0.02)	1.458 (3)	0.692
95% CI	–0.37 to 0.00	–1.00 to 0.03	–4.00 to 0.00	–2.00 to 0.00		
SPRS (Relative Form)						
Pre-inter	44.50 (37.00; 51.25)	47.00 (40.00; 57.00)	54.00 (40.50; 67.50)	51.50 (47.75; 56.00)	3.703 (3)	0.295
Change	6.00 (0.00; 14.25)	0.00 (0.00; 5.00)	0.00 (–4.0; 5.0)	0.00 (0.00; 6.25)	6.039 (3)	0.110
95% CI	0.50 to 11.00	–4.00 to 4.00	0.00 to 3.60	0.00 to 6.00		

S-A: self-awareness; CAMPROMPT: Cambridge Behavioural Prospective Memory Test; CAPM: Comprehensive Assessment of Prospective Memory; SPRS: Sydney Psychosocial Reintegration Scale; 95% CI: 95% confidence interval for the median change scores; df: degrees of freedom.

to have a significantly larger change scores than those without ($p = 0.017$). Among the 4 groups of participants, the group that received both self-awareness and compensatory PM training did not have the largest change score on this variable.

CAPM relative rating

Table II shows the relative ratings on the CAPM (pre-intervention and change score) of the 4 groups. Neither the pre-intervention rating nor the change score were significantly different among the 4 groups.

Sydney psychosocial reintegration scale (relative rating)

Relatives were asked to rate participants using the SPRS before and after the intervention to evaluate whether PM compensatory and self-awareness training would lead to improvement in everyday functioning (see Table II). Neither the pre-intervention rating nor the change score were significantly different among the 4 groups.

DISCUSSION

The study evaluated the efficacy of self-awareness and compensatory training in the rehabilitation of PM in adults with TBI using a randomized control design with 4 dependent measures. Significant effects were found for 2 of the 4 measures, 1 involving a standardized assessment of PM (the CAMPROMPT) and the other an assessment of strategy use in everyday life (number of valid diary entries). Together these data are encouraging, in indicating that problems of PM can be rehabilitated to some degree in patients with TBI using a relatively brief (8-week) and low intensity (1.5–2 h per week) intervention.

Table III. *Number of participants taking notes on Cambridge Behavioural Prospective Memory Test*

	S-A plus compensatory training	Active control plus Compensatory training	S-A training plus Active control	Active control
Pre-test	5	5	4	6
Post-test	9	10	5	7

S-A: self-awareness.

In interpreting the data, however, pre-existing differences among the groups need to be borne in mind. As can happen with random assignment, groups showed some differences at pre-intervention, particularly in terms of time since injury and length of PTA. Although the differences were not statistically significant, they were sufficiently large to raise the prospect of a confounding with intervention in accounting for change in the dependent variables. For example, length of PTA, an index of severity of TBI, was greater in the groups administered self-awareness training than in the other 2 groups and this may account for a lack of difference for this variable.

That said, the results of the study were largely as predicted for compensatory PM training. Those groups receiving compensatory training showed significantly larger changes on CAMPROMPT and on the number of valid diary entries than the other groups. In the case of CAMPROMPT, which is a standardized psychometric test of PM, the change was of clinical as well as of statistical significance, as the median scores of the 2 groups that received compensatory training moved their performance level on this test from the range of poor to average functioning, according to stratified age norms. The effect on the number of valid diary entries points to the generalization of the effect of compensatory training to everyday living. Significantly greater change on this measure was found for groups receiving compensatory training than for those that were not. A possible basis for this may lie in the change in the number of participants using note-taking on the CAMPROMPT from pre- to post-intervention. This number almost doubled in the case of compensatory training and was statistically significant, and note-taking was found to correlate significantly with change in CAMPROMPT score.

Whether developing note training is the critical element in the compensatory training programme employed will require further detailed study. The programme used in this study included diary use, note-taking, and organizational techniques, among others, and it is premature to identify a single element as the active one.

Although there was evidence of generalization of compensatory training in the data on diary entries, the generalization of effect was, however, limited in that neither the relatives' ratings of PM failures nor their ratings of psychosocial re-integration showed significant effects. Indeed, median change on these measures was zero for most groups. Longer term follow-up than was possible here may be necessary to show broad generalization of the effects of compensatory training.

The results for self-awareness training were not as expected. On the basis of theory and an earlier case study, self-awareness training was predicted to have a significant effect on PM, but in no case were statistically significant effects obtained. In fact, increase in the number of participants who took notes was greater for the 2 groups not receiving self-awareness training than for the 2 groups that did. The possibility that pre-existing differences, as indexed by length of PTA, confounded the effect was raised earlier. It may also be the case that more substantial training in self-awareness than conducted here is necessary if statistically significant change as a consequence of this type of training is to be demonstrated. The influence of self-awareness training requires further study, but in the meantime the combination of self-awareness and compensatory training as a package is not supported by the present findings.

Overall, our findings provide some evidence to suggest that when time and therapy resources are limited, as they often are in the rehabilitation environment, it is more effective to provide a limited amount of compensatory training for PM problems than it is to embark on a remedial training programme. Often in clinical practice, however, a combination of both remedial and compensatory approaches are used, with the emphasis varying according to the length of time post-injury, and other individual characteristics of the patients (35).

Among the limitations of the trial reported here was the fact that only 45 of 82 initially consenting participants took part. Although there were practical and personal reasons for this, the representativeness of the sample is compromised by such a high attrition rate. The study would have benefited too from a larger sample size. Moreover, 1 of the 4 groups (viz. active control only) had more participants drop out than the other 3 groups (4 compared with 1 or 2). This is perhaps understandable given that the combined content of these intervention sessions for this group could be perceived as less interesting. The problem of pre-existing differences among groups has also been noted, as has the absence of a longer term follow-up. These limitations noted, the results of this random control trial point to a promising beginning for studies identifying the efficacy of training programmes of PM in patients with TBI.

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REFERENCES

1. Kvavilashvili L, Ellis J. Varieties of intention: some distinctions and classifications. In: Brandimonte M, Einstein GO, McDaniel MA, editors. Prospective memory: theory and applications. Mahwah: Erlbaum; 1996, p. 23–51.
2. McDaniel MA, Einstein, G O. Prospective memory: an overview and synthesis of an emerging field. Los Angeles: Sage; 2007.
3. Fleming JM, Shum D, Strong J, Lightbody S. Prospective memory rehabilitation for adults with traumatic brain injury: a compensatory training programme. Brain Inj 2005; 19: 1–10.
4. Henry JD, Phillips LH, Crawford JR, Kliegal M, Theodorou G, Summers F. Traumatic brain injury and prospective memory: Influence of task complexity. J Clin Exp Psychol 2007; 29: 457–466.
5. Mathias JL, Mansfield KM. Prospective and declarative memory problems following moderate and severe traumatic brain injury. Brain Inj 2005; 19: 271–282.
6. Roche NL, Fleming JM, Shum D. Self-awareness of prospective memory failure in adults with traumatic brain injury. Brain Inj 2002; 16: 931–945.
7. Schmitter-Edgecombe M, Wright MJ. Event-based prospective memory following severe closed-head injury. Neuropsychology 2004; 18: 353–361.
8. Shum D, Valentine M, Cutmore, T. Performance of individuals with severe long-term traumatic brain injury on time-, event-, and activity-based prospective memory tasks. J Clin Exp Neuropsychol 1999; 21: 49–58.
9. Levine B, Katz DI, Dade L, Black SE. Novel approaches to the assessment of frontal damage and executive deficits. In: Stuss DT, Knight RT, editors. Priniciples of frontal lobe function. New York: Oxford University Press; 2002, p. 51–84
10. Stuss DT, Alexander MP. Executive functions and the frontal lobes: a conceptual view. Psychol Res 2000; 63: 289–298.
11. Shum D, Fleming, J M, Neulinger K. Prospective memory and traumatic brain injury: a review. Brain Impair 2002; 3: 1–16.
12. Fleming J, Riley L, Gill H, Gullo MJ, Strong J, Shum D. Predictors of prospective memory in adults with traumatic brain injury. J Int Neuropsychol Soc 2008; 14: 823–831.
13. Groot YCT, Wilson BA, Evans J, Watson P. Prospective memory functioning in people with and without brain injury. J Int Neuropsychol Soc 2002; 8: 645–654.
14. Martin M, Kliegel M, McDaniel MA. The involvement of executive functions in prospective memory performance of adults. Int J Psychol 2003; 38: 195–206.
15. Wilson B. Management and remediation of memory problems in brain-injured adults. In: Baddeley AD, Kopelman MD, Wilson BA, editors. The handbook of memory disorders. 2nd edn. Chichester: Wiley; 2002, p. 617–636.
16. Glisky, EL. Acquisition and transfer of word processing skill by an amnesic patient. Neuropsychol Rehabil 1995; 5: 299–318.
17. Sohlberg MM, White O, Evans E, Mateer C. Background and initial case studies into the effects of prospective memory training. Brain Inj 1992; 6: 129–138.
18. Sohlberg MM, White O, Evans E, Mateer C. An investigation of the effects of prospective memory training. Brain Inj 1992; 6: 139–154.
19. Raskin SA, Sohlberg MM. The efficacy of prospective memory training in two adults with brain injury. J Head Trauma Rehabil 1996; 11: 32–51.
20. van den Broek MD, Downes J, Johnson Z, Dayus B, Hilton N. Evaluation of an electronic memory aid. Brain Inj 2000; 14: 455–462.

21. Kim HJ, Burke DT, Dowds MM Jr, Robinson Boone KA, Park GJ. Electronic memory aids for outpatient brain injury: follow-up findings. Brain Inj 2000; 14: 187–196.
22. Kirsch NL, Shenton M, Rowan J. A generic, 'in house', alphanumeric paging system for prospective activity impairments after traumatic brain injury. Brain Inj 2004; 18: 725–734.
23. Fish J, Evans JJ, Nimmo M, Martin E, Kersel D, Bateman A, et al. Rehabilitation of executive dysfunction following brain injury: content-free cueing improves everyday prospective memory performance. Neuropsychologia 2007; 45: 1318–1330.
24. Donaghy S, Williams W. A new protocol for training severely impaired patients in the usage of memory journals. Brain Inj 1998; 12: 1061–1076.
25. Schmitter-Edgecombe M, Fahy JF, Whelan JP, Long CJ. Memory remediation after severe closed head injury: notebook training versus supportive therapy. J Consult Clin Psychol 1995; 63: 484–489.
26. Sohlberg MM, Mateer CA. Training use of compensatory memory books: a three stage behavioural approach. J Clin Exp Neuropsychol 1989; 11: 871–891.
27. Ownsworth TL, McFarland K. Memory remediation in long-term acquired brain injury: two approaches in diary training. Brain Inj 1999; 13: 605–626.
28. Schmitter-Edgecombe M, Woo E. Memory self-awareness and memory self-monitoring following severe closed-head injury. Brain Inj 2004; 18, 997–1016.
29. Wechsler D. Wechsler Abbreviated Scale of Intelligence. San Antonio: The Psychological Corporation; 1989.
30. Wilson B, Emslie H, Foley J, Shiel A, Watson P, Hawkins K, et al. Cambridge Prospective Memory Test (CAMPROMPT) Manual. Oxford: Harcourt Assessment; 2005.
31. Chau L T, Lee JB, Fleming J, Roche N, Shum D. Reliability and normative data for the Comprehensive Assessment of Prospective Memory (CAPM). Neuropsychol Rehabil 2007; 17: 707–722.
32. Fleming J, Kennedy S, Fisher R, Gill H, Gullo M, Shum D. Validity of the Comprehensive Assessment of Prospective Memory (CAPM) for use with adults with traumatic brain injury. Brain Impair 2009; 10: 34–44.
33. Tate R, Hodgkinson A, Veerabangsa A, Maggiotto S. Measuring psychosocial recovery after traumatic brain injury: psychometric properties of a new scale. J Head Trauma Rehabil 1999; 14: 543–557.
34. Kopelman M, Wilson B, Baddeley, A. The autobiographical memory interview. Suffolk, UK: Thames Valley Test Co.; 1990.
35. Grieve J, Gnanasekaran L. Neuropsychology for occupational therapists: cognition in occupational performance. Oxford: Blackwell Publishing; 2008.