Event-Based Prospective Memory
Following Adult Traumatic Brain Injury

by

Brigitte N. Patry-
B.A., Université d’Ottawa, 1995
M.A., Carleton University, 1999

A Dissertation Submitted in Partial Fulfillment of the
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University of Victoria

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Abstract

Objectives: The ability to remember to carry out future intentions (prospective memory or ProM) has been shown to be impaired in individuals with severe traumatic brain injury (TBI). However, it is not known whether such deficits extend to people with milder TBI. This study sought to investigate the status of event-based ProM in a sample with a wide range of TBI severity. Furthermore, it proposed to determine whether perceptually salient cues and the formation of implementation intentions, shown to be beneficial in other populations, are also helpful for people with TBI. A detailed error analysis was performed, and the relationship of objective ProM performance to subjective ProM and to scores on other cognitive tests was investigated in an attempt to clarify the mechanisms underlying ProM performance post-TBI.

Method: The sample consisted of 20 individuals who sustained a mild (n=10) or severe (n=10) TBI at least 6 months earlier and 20 age-, gender-, and education-matched healthy adults below the age of 55. The groups did not differ in terms of level of pain or substance abuse; however, the TBI group endorsed more symptoms on the Beck Depression Inventory-II (BDI-II) and on the Beck Anxiety Inventory. They completed two event-based ProM tasks, a game entitled Navigating Your Week (NYW) and the Prospective Remembering of Actions and Sentences (PROAS). Each measure was designed to create intentions that would prompt different actions in response to various
cues. They also completed the Prospective and Retrospective Memory Questionnaire (PRMQ) to assess subjective evaluation of memory, the Rey Auditory Verbal Learning Test (RAVLT) and cued recall tasks to assess retrospective memory, and Digit Span Backward to measure working memory.

**Results:** Participants with TBI scored significantly below controls on the NYW game, even after controlling for BDI-II scores, and the two TBI subgroups performed similarly. Participants with TBI made more ProM failures and loss of content errors than controls on the NYW game. The groups performed similarly on the PROAS when it was the second ProM task administered. Although salient cues increased the frequency of responding upon cue presentation, they did not increase response accuracy and thus, did not result in greater fulfillment of intentions. The formation of implementation intentions did not enhance the ability to carry out previously formed intentions. The TBI group’s performance on the NYW and on the PROAS was associated with their scores on Digit Span Backward and on cued recall measures. The PROAS was also related to delayed recall on the RAVLT; the association between the NYW and the RAVLT did not reach statistical significance. The TBI group endorsed more prospective and retrospective memory problems on the PRMQ as compared to the control group, but their self-ratings were not significantly related to their ProM performance.

**Conclusions:** Individuals with TBI fulfilled fewer of their intentions than controls, particularly on the NYW game, because they failed to respond to cues and had more difficulty remembering the content of their intentions. Their reduced ProM was not fully attributable to depressive symptomatology and was not related to their subjective ProM complaints, despite their greater ProM concerns as compared to controls. Deficits may be attenuated when ProM situations emphasize more automatic retrieval as compared to strategic monitoring processes. Working memory and retrospective memory may both contribute to ProM status after TBI. Cue saliency did not help TBI participants to carry out more intentions; however, it reduced the frequency of ProM failures. The lack of implementation intention effects may be related to study design characteristics. The NYW game appears to be a sensitive, valid, and reliable tool that could be useful in a rehabilitation setting.
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Dedication

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To Rob, my pillar of strength, my partner and soulmate.

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To Angèle, my lifelong friend, for her support and her pride in my accomplishments.

To my late grandmother, "memère," who always showed an interest in my studies and took pride in referring to me as "doctor."
Introduction

In everyday life, people often must remember to perform an intended action at some point in the future while engaged in a different activity; this is termed prospective memory (ProM). Examples of ProM include remembering to mail a letter the next time we go out, to take medication nightly at bedtime, and to pick up dry cleaning after work. Recall and execution of an intended action may be determined (1) by the presence of a specific external event or (2) by a specific time or elapsed amount of time (Einstein & McDaniel, 1990). As such, remembering to buy milk when driving by the grocery store represents an event-based ProM task while remembering to take the laundry out of the dryer after 30 minutes is an example of a time-based ProM activity.

Two components of ProM have been identified and are receiving increasingly more attention (Einstein & McDaniel, 1990; Kvavilashvili, 1987). The prospective component refers to remembering at the appropriate moment that one must perform some action (remembering to remember) whereas the retrospective component involves remembering the content of the intended action (remembering what has to be done). For example, remembering that something needs to be done when driving by the grocery store is the prospective component and remembering that bread needs to be purchased is the retrospective component.

Because ProM is necessary to carry out actions that can have important repercussion on our lives (e.g. remembering to take medications impacts on our health, remembering to pay a bill can affect our financial situation), a difficulty remembering to carry out intentions can interfere with independent living (Groot et al., 2002). Forgetting
to perform intended actions is a common symptom associated with traumatic brain injury (TBI) (e.g., Shum et al., 1999), or more globally with acquired brain injury (e.g., Groot et al., 2002), which comprises TBI, stroke, and other brain injuries not present at birth.

Deficits in ProM were reported as the main symptom in 40% of patients presenting to a memory disorder clinic (Kliegel & Martin, 2003). Prospective memory deficits can have an impact on the efficacy of rehabilitation efforts post-TBI (e.g., taking medications, completing homework) (Shum et al., 1999). Nevertheless, relatively few published studies on TBI have investigated the ability to remember to perform future tasks and most of the studies have focused exclusively on individuals with severe TBI.

One goal of this dissertation was therefore to determine whether event-based ProM deficits reported in groups with severe TBI extend to a sample of individuals with milder injury severity. Two other objectives were to assess whether people with TBI benefit from two manipulations shown to enhance prospective remembering or completion of intentions in other cognitively vulnerable populations. Manipulations involve the perceptual distinctiveness of a cue and the formation of implementation intentions (specific intentions that lead to automatic control of a behaviour by an environmental cue). If such manipulations are successful, they may suggest ways to facilitate prospective remembering in everyday situations to promote the independence of brain-injured individuals. The last main objective of this study was to perform a detailed analysis of the types of errors made by individuals with TBI on event-based ProM tasks. The results may be useful to identify appropriate environmental modifications, to design ProM aids that would minimize such errors, or both. They may also provide some insight into the
mechanism(s) underlying ProM performance after TBI. Secondary goals of this study included evaluation of the link between event-based ProM and retrospective memory performance in TBI and assessment of the relationship between self-reported and objective ProM performance in this patient group. Prior to a more thorough discussion of the rationale for this study, empirical findings pertaining to ProM post-TBI will be reviewed.

**Self-Reported Prospective Memory Functioning Post-TBI**

When evaluating subjective appraisal of memory difficulties by individuals with TBI, Mateer et al. (1987) found that both people with or without TBI reported greater difficulty with ProM than with more retrospective types of memory (requiring recall of things past). Subsequent investigations in the area of ProM in TBI focused on self-reported memory functioning and its relationship to objective ProM performance (e.g., Hannon et al., 1995; Kinsella et al., 1996). In a study by Hannon et al. (1995), the TBI group reported more problems than the control group in terms of memory for habitual tasks to be carried out in the short-term (e.g., putting a stamp on an envelope) (Hannon et al., 1995). When the groups were combined, participants who claimed to have more problems remembering to carry out their intentions in daily life performed more poorly on both event- and time-based ProM tasks. However, no correlations were run for the TBI group separately. Furthermore, the authors did not statistically control for depression despite the fact that self-reported depressive symptomatology was associated with lower ProM scores and with reports of more frequent failures to carry out intended actions. Therefore, the link between self-reported and objective ProM performance may have been
mediated by depression.

Kinsella et al. (1996) also assessed the link between self-reported memory and objective event-based ProM performance. On the Memory Functioning Questionnaire (MFQ; Gilewski et al., 1990), 24 severely brain-injured participants reported a decline in recent memory that significantly exceeded the memory changes noted by 24 controls. The self-reported decline was associated with failure to request a questionnaire at the end of the session but not with performance on a more naturalistic ProM task, namely returning a form by mail. The discrepancy between these results may have been related to the lack of control over the use of external aids during naturalistic activities (e.g., help from a spouse). Other aspects of self-reported memory functioning, such as frequency of forgetting and seriousness of such errors, were not related to ProM performance. Because TBI participants acknowledged greater deterioration in memory functioning but not more frequent or serious forgetting compared to controls, the authors suggested that the TBI group may lack insight into the implications of memory decline on everyday life. In a more recent study, the performance of individuals with acquired brain injury on laboratory-based ProM tasks (Groot et al., 2002) was associated with collateral evaluations of the frequency of their failures of everyday memory but not with participants’ own memory self-ratings.

The discrepancy between self-reported and objective ProM performance has been assumed to reflect the inability of people with TBI to accurately judge their ProM status due to lack of insight, psychological defense, or neurological injury (Kinsella et al., 1996; Sohlberg & Mateer, 2001). Alternatively, the presence of memory problems may preclude
individuals from being able to accurately recall memory failures (Kinsella et al., 1996). It is also possible that the questionnaires and laboratory tasks do not measure the same construct (Zeint et al., 2006).

**Prospective Memory Task Performance**

Investigations of objective ProM performance in adults with TBI originally involved naturalistic tasks, namely returning a form or questionnaire by mail after inscribing the date (or the date and their name) on it (Hannon et al., 1995; Kinsella et al., 1996). The return rate was similar for patients and controls in both studies. However, participants with TBI more often forgot to include the date and their name (Hannon et al., 1995). A significant limitation of these studies lies in the lack of control over the use of mnemonic aids and help received, which precludes inferences regarding true ProM abilities.

Despite adequate performance on naturalistic tasks, individuals with TBI typically perform more poorly on laboratory measures of time- and event-based ProM compared to healthy adults. Using four ProM tasks, Hannon et al. (1995) compared the performance of a group of 15 outpatients (> 1 year post-TBI), most of whom had been in a coma, with that of healthy adults. The tasks, administered in a group format, involved either associative (event-based) or time-based cues and were carried out either 2 or 5 minutes following relevant task instructions. The group with TBI obtained a lower overall score on the tasks but no distinction was made between event- and time-based task conditions. Furthermore, given that patients with TBI often show attentional difficulties (Cicerone, 1997) and were tested in a group setting, reduced ProM performance may also be related to problems with
distractibility. Prospective memory performance was related to scores on the Beck Depression Inventory (BDI; Beck, 1978) in both control and patient groups. Failure to statistically control or screen for the presence of mood disorders is a common methodological shortcoming of most studies of ProM in TBI. As shown by Hannon et al. (1995), depression relates to performance on short-term ProM tasks but the relative contribution of depression and brain injury to ProM performance remains to be investigated.

Cockburn (1996) investigated the performance of 18 inpatients with various types of brain injuries (< 1 year post-injury) on measures of event- and time-based ProM. The event-based task involved changing pens when encountering 3-digit numbers among 2-digit numbers on a cancellation task. It also required initialing the last page of the test booklet. On the time-based task, participants were asked to start a timer prior to a sentence verification task and to stop the task and timer after 5 minutes. The patient group was impaired on both measures relative to healthy controls. Because the brain-injured group also showed reduced scores on the National Adult Reading Test (NART; Nelson, 1982), a measure sometimes used to estimate premorbid intelligence, group differences cannot unequivocally be associated with the effects of a TBI. Furthermore, some patients were in the acute stages of recovery and no information was obtained regarding depressive symptoms.

A more rigorous study by Shum et al. (1999) addressed some of the limitations of previous studies, such as the small number of test items and the use of dichotomous scoring criteria (pass or fail). The authors increased the number of cues and calculated the
percentage of correct responses, thus allowing for more reliable test scores. Furthermore, this study improved on previous ones by: (1) asking participants to repeat task instructions, (2) counterbalancing the order of task presentation, and (3) analyzing performance on the filler activity to ensure this was not confounding performance on the ProM tasks. The authors investigated the performance of individuals with severe TBI across event-, time-, and activity-based ProM tasks. Unlike time- and event-based tasks, activity-based tasks do not require interruption of an ongoing activity (Kvavilashvili & Ellis, 1996), though they occur in response to an external cue (e.g., turning off the light when exiting a room). Twelve individuals seen at least one year post-TBI and 12 healthy controls were asked to phone the experimenter to report their score at predetermined times during a general knowledge task. They were asked to telephone either when they saw the word “Prime Minister” on the screen (event-based; cue recurred 5 times) or every 5 minutes (time-based). Participants could keep track of time by pressing the “t” key. The activity-based task consisted of switching off the monitor, writing down their score on a whiteboard, and switching off a light outside the laboratory at the end of the general knowledge task. Findings indicated impaired performance by the TBI group across all types of ProM tasks despite similar performance on the filler activity by both groups. The percentage of correct responses across event- and time-based tasks was 65.83% and 89.23% for the TBI and control group, respectively. Performance on the time-based task was lowest for both groups but not disproportionately impaired relative to the event-based task in either the brain-injured or the control group. The activity-based task yielded the best performance, possibly because of its minimal emphasis on self-initiated processes and
executive skills (Cockburn, 1995). All participants correctly recalled task requirements at the end of the study. Despite the strengths of this study, the authors did not distinguish whether response to the same cue varied across time (i.e., whether there were fluctuations in response to a particular cue). Furthermore, as with previous studies, depressive symptomatology was not assessed.

Mateer et al. (2000) also found reduced ProM performance by 14 young traumatically brain-injured individuals compared to a group of healthy young adults across time- and event-based tasks. Patient performance was similar to that of older adults. This study employed the Prospective Memory Test (PMT; Raskin & Buckheit, 1998), a measure comprised of eight event-based and eight time-based tasks, carried out at intervals of 2 or 15 minutes following relevant instructions. The TBI group was impaired regardless of time interval and type of response required (action or verbal). As with other studies, however, depression was not assessed. Furthermore, the groups were not matched for years of education unlike in other studies on ProM post-TBI (e.g., Hannon et al., 1995; Schmitter-Edgecombe & Wright, 2004; Shum et al., 1999).

Groot et al. (2002) investigated various aspects of ProM in a group of 36 individuals with brain injuries of various etiologies (predominantly TBI), mostly incurred at least six months earlier. Four time- and four event-based tasks were administered as part of a modified version of the Cambridge Behavior Prospective Memory Test (CBPMT; Wilson & Evans, reported in Kime et al., 1996). Items required either a verbal or a nonverbal response and sometimes necessitated interruption of neuropsychological tests serving as filler activities. The brain-injured group was impaired on both types of
tasks relative to a control group, although both groups performed more poorly on time-based tasks. Group differences were not due to differences in age, gender, years of education, pre-morbid or current intellectual functioning. Although this study addressed important questions, there were several methodological limitations. Comprehension of task instructions was not ensured, there was no evaluation of memory for the content of the tasks, dichotomous scoring was used, details of the filler and ProM tasks were not provided (e.g., time interval), and no details were given regarding the assessment of depression.

Schmitter-Edgecombe and Wright (2004) investigated the extent to which ProM performance on an ongoing task relies on focal processing of the ProM cue. Twenty-four individuals with severe TBI (> 1 year post-injury) and healthy controls performed an event-based ProM task embedded within a verbal working memory paradigm requiring them to keep track of the last 3 words presented on the screen. Participants were randomly assigned to two groups: focal cue and peripheral cue. People in the focal cue condition were asked to press a particular key whenever the word “stone” appeared on the screen (6 times). Individuals in the peripheral cue condition were required to press a particular key whenever the background pattern changed (6 times). Consistent with other studies, the TBI group had a higher number of ProM failures (omissions), and this was observed under both conditions despite similar performance by both groups on the working memory task. Analysis of forgetting and recovery patterns (successful response to a cue followed by a failure to respond and vice-versa) indicated that the performance of the TBI group tended to fluctuate throughout the task. According to the authors, this
fluctuation may be related to momentary lapses of “intentions” rather than to forgetting of task instructions.

Carlesimo et al. (2004) separated the ability of people with chronic severe TBI to remember to perform intentions at the appropriate moment (prospective component) and the ability to remember specific actions to be performed (retrospective component) on event- and time-based ProM tasks. For the time-based task, participants had to perform three different actions after either 10 or 45 minutes while engaging in cancellation tasks and computer-based vigilance tests. In the event-based condition, the ringing of a timer signaled the moment to perform another set of three actions. Failure to respond upon cue presentation was viewed as a problem with the prospective component. The retrospective component of ProM was measured as a failure to recall the content of the intention when queried about having to do something two minutes after there was no response to a cue. The authors indicated that TBI participants had problems with the prospective component that were likely attributable to reduced frequency and strategic use of time monitoring and self-reminders. They suggested that episodic memory deficits may explain their TBI participants’ difficulty with the retrieval of specific intentions.

The most recent investigation of ProM in TBI (Knight et al., 2006) employed a virtual paradigm designed to simulate a shopping trip. Chronic survivors of severe TBI and normal controls had to “walk” down a street and enter various shops to complete a list of errands to which they consistently had access. During this ongoing activity, the ProM task required them to respond to three targets that appeared multiple times. The level of distraction was manipulated using real-life visual stimuli and sounds (e.g., car horns,
people moving around). For the ongoing activity, TBI participants failed to notice shops only in the presence of significant distractors. By contrast, they showed floor effects on the ProM task, on which they were outperformed by the controls regardless of the level of distraction.

In sum, previous studies of ProM have focused on individuals with severe TBI and have compared their performance on different time-based and event-based ProM tasks to that of controls. The impact of distraction and the role of focal processing of cues on ProM performance have also been investigated. Lastly, there have been attempts to identify the underlying cognitive processes mediating ProM performance by either examining the prospective and retrospective components of ProM or by correlating ProM performance with scores on tests measuring other cognitive functions, as will be described later.

**Processes Underlying Prospective Memory**

The mechanisms underlying ProM decline post-TBI remain unclear, although executive functions, retrospective memory, and attention are postulated to be implicated in ProM. Because of the hypothesized involvement of executive functions in successful prospective remembering, the term “realization of delayed intentions” has been used to refer to ProM (Ellis, 1996). Executive functions encompass a variety of cognitive processes underlying goal-directed behaviours and presumed to be subserved by the frontal lobes (e.g., Stuss & Benson, 1986; Tranel et al., 1994). Executive function-related cognitive processes with hypothesized involvement in ProM include: (1) planning (Dobbs & Reeves, 1996; Shimamura et al., 1991), (2) inhibition of an intention until the
appropriate moment for its execution (Cockburn, 1995), (3) monitoring of the environment for the cue (Bisiacchi, 1996; Burgess & Shallice, 1997) due to the need to identify a cue as a significant signal and then self-initiate a search of memory (McDaniel et al., 1999), (4) switching attention between tasks as well as interrupting the ongoing activity (McDaniel et al., 1999), and (5) initiating the intention (Martin et al., 2003). Working memory, which refers to the capacity to maintain information while it is being actively manipulated, is also assumed to play a role in ProM. It may enable periodic self-reminders of the intention during the delay (Kliegel et al., 2000) and maintain the goals of both the ProM and ongoing task in mind (McDaniel et al., 1999).

Several authors have theorized that ProM is closely tied to the prefrontal systems (Bisiacchi, 1996; Burgess & Shallice, 1997; Glisky, 1996). According to Shimamura (1990), memory disorders observed in patients with frontal lobe lesions are disorders of ProM. These disorders involve processes responsible for the strategic and executive (e.g., organization, planning, monitoring, and initiation of efficient encoding and retrieval strategies) rather than storage aspects of memory (Shimamura et al., 1991). Strategic processes, thought to be linked to the prefrontal cortex (Moscovitch, 1994; Shimamura et al., 1991), may allow retrieval of the intended action after a cue is noticed (McDaniel & Einstein, 1993). Frontal areas may also be implicated in helping to form a highly activated encoding of the cue and intended action (Burgess & Shallice, 1997; McDaniel et al., 1999). Studies using event-related potentials support the involvement of the frontal lobes in ProM (West et al., 2000) and specifically suggest that the formation (Leynes et al., 2003) and retrieval of intentions is mediated by the right ventrolateral area (Leynes et
al., 2003; Okuda et al., 1998). Other evidence for involvement of the frontal lobes in ProM comes from a single case study by Cockburn (1995) of a patient with bilateral frontal infarcts who showed selective impairment on time-based tasks requiring interruption or switching from the ongoing activity to the ProM task. According to Cockburn (1995), the results suggest a failure to self-initiate the intended action at the appropriate moment that may be associated with poor attentional and inhibitory control. Finally, Umeda et al. (2006) provided evidence that the ventral and medial parts of the frontal lobes may mediate the prospective component of ProM based on the differential performance of two patients with brain injury localized to either the frontal or the temporal lobe region.

In groups of people with TBI, performance on ProM tasks has not been consistently correlated with scores on formal tests of executive functions. Groot et al. (2002) reported a link between ProM performance and scores on the Modified Card Sorting Test (Nelson, 1976), Trail Making Test (Reitan, 1958), and Backward Digit Span of the Wechsler Memory Scale-Revised (WMS-R; Wechsler, 1987). On the other hand, ProM performance was unrelated to performance on the Controlled Oral Word Association Test (COWAT; Spreen & Benton, 1977) (Cockburn, 1996; Groot et al., 2002; Schmitter-Edgecombe & Wright, 2004), the Modified Six Elements subtest of the Behavioral Assessment of the Dysexecutive Syndrome (BADS; Wilson et al., 1996) (Groot et al., 2002), the Wisconsin Card Sorting Test (WCST; Heaton, 1981) (Cockburn, 1996; Schmitter-Edgecombe & Wright, 2004), and the Color-Word Stroop Test (Stroop, 1935) (Groot et al., 2002; Schmitter-Edgecombe & Wright, 2004). Self and others’
reports of everyday errors and problems in executive functions have not been correlated with ProM performance (Groot et al., 2002). According to Martin et al. (2003), the association between ProM and executive functions may depend on the extent to which the ProM task focuses on the formation and execution of intentions compared to the retention phase. Cockburn (1996) attributed the lack of an association to the different underlying processes tapped by the tests administered or to insensitivity of the measures.

Retrospective memory is also thought to contribute to ProM because both involve memory for content (Cockburn, 1995). Furthermore, event-based ProM tasks and cued retrospective memory tasks require that an association be formed between a target event (cue) and particular information (the associated stimulus or intention) (Einstein et al., 1992). A recent study by Umeda et al. (2006) suggested that the medial temporal lobe and adjacent areas may be involved in the retrospective component of ProM. The episodic memory system that supports memory for previous events is likely responsible for storing the intended action and its link with a pre-specified cue (Carlesimo et al., 2004; Ellis, 1996). Most investigations of ProM have included the administration of a measure of episodic memory to assess its relationship to ProM in TBI. For example, Groot et al. (2002) reported that recall of the Rey Complex Figure Test (Osterrieth, 1944), and recognition of words and faces on the Recognition Memory Test (Warrington, 1984) was associated with performance on event- and time-based ProM tasks in a brain-injured group. Similarly, in a sample of 18 inpatients with various types of brain injury, Cockburn (1996) found that retrospective memory performance measured by the Rivermead Behavioural Memory Test (RBMT; Wilson et al., 1985) and by Logical
Memory of the Wechsler Memory Scale (WMS; Wechsler, 1945) was linked to success or failure on an event-based task. However, the findings did not extend to a time-based task. In a study by Schmitter-Edgecombe and Wright (2004), participants with TBI who obtained the lowest scores on the California Verbal Learning Test Long-Delay Free Recall (CVLT; Delis et al., 1987) and on the delayed Visual Reproduction subtest of the WMS-R (Wechsler, 1987) tended to have more ProM failures on an event-based task. The delayed Logical Memory subtest of the WMS-R (Wechsler, 1987) has been inconsistently related to ProM performance (Groot et al., 2002; Schmitter-Edgecombe & Wright, 2004).

A few studies have attempted to disentangle the effects of retrospective memory and executive functions on ProM in brain-injured adults. Groot et al. (2002) reported that ProM differences between brain-injured and control groups could be accounted for by slower speed of processing as well as by performance differences on tests of retrospective memory, attention, and executive functions as a whole, but not individually. The authors viewed their findings as supportive of the assumption that retrospective memory and executive functions are important processes involved in both time- and event-based ProM tasks. Another study found that TBI participants’ performance on event- and time-based ProM tasks was better accounted for by scores on executive function tests than by scores on retrospective memory tests, except in cases of severe anterograde amnesia (Mateer et al., 2000). Similar results were reported by Kopp and Thöne-Otto (2003) in a sample of adults with various types of brain injury (mostly TBI). The authors administered an event-based task embedded in a verbal working memory paradigm. Participants with brain injury were classified into four groups based on their level (high-low) of
retrospective memory and executive function performance as determined by the delayed recall index of the WMS-R and the BADS, respectively. Although none of the groups differed with respect to the ongoing working memory task, participants with brain injury with impaired executive functions obtained the lowest scores on the ProM activity. On the other hand, there was no effect of retrospective memory status on ProM performance. As stated by Burgess and Shallice (1997), retrospective memory may be intact despite ProM impairment due to the contribution of several other underlying processes (such as executive functions) to ProM (see also Shimamura et al., 1991). Alternatively, and as argued by Einstein and McDaniel (1990), the lack of association between retrospective memory and ProM may be related to the low retrospective memory component involved in a particular ProM activity (Kopp & Thöne-Otto, 2003). The fact that several individuals who showed severe anterograde amnesia during the training period were excluded also led the authors to suggest that retention of basic retrospective memory skills is mandatory for successful ProM performance, particularly in terms of encoding and retaining the intention during the delay preceding the realization of the intention.

Nevertheless, groups with low retrospective memory or low executive functioning performance both remembered fewer cues than controls during a free recall test administered at the end of the study.

**Prospective Memory Errors**

Another way to investigate the processes underlying ProM impairment in individuals with TBI is to analyze their pattern of errors on ProM tasks. Two primary types of errors that can lead to failure to carry out an intention correspond to the
prospective and retrospective components of ProM described earlier (remembering to remember versus remembering what has to be done) (Einstein & McDaniel, 1990; Einstein et al., 1992; Kvavilashvili, 1987). For example, failure to get groceries on the way home from work despite having formed that intention could be attributable to forgetting one’s intention to get groceries at that particular moment or to forgetting which item had to be purchased despite remembering to stop at the grocery store. In older adults, differential impairment of each component (e.g., Cohen et al., 2001; West & Craik, 2001) supports a two-component view of ProM.

It is possible that failure to respond to a cue is due to an inability to remember what to do despite cue detection. To assess this in older adults, West and Craik (2001) calculated the proportion of cues that failed to elicit a response (omissions) and the proportion of cues reported to be detected but that did not trigger retrieval of the correct intention (confusions). To minimize the possibility of a non-response being misclassified as failure of the prospective component, participants can be asked to inform the experimenter if they notice a cue but cannot recall the action to be carried out (Shapiro & Khristman, 1999). A common way to assess the retrospective component of ProM has been to ask participants to recall the intended action either freely or when provided with the associated cue during task debriefing.

Error type has not been systematically or extensively studied in people with TBI. Studies either did not analyze the reason for failure to carry out ProM tasks and failed to assess recall of task instructions, cues, and intended actions (Groot et al., 2002; Schmitter-Edgecombe & Wright, 2004) or else provided only informal observations of error types.
For example, groups of people with TBI are reported to have difficulty remembering the content of intentions (Hannon et al., 1995; Kopp & Thöne-Otto, 2003) but the extent to which such difficulty contributed to ProM scores is unknown. In the study by Kopp and Thöne-Otto (2003), patients with impairment on either retrospective memory or executive function measures remembered fewer cues on a post-test free recall measure.

Difficulty with the prospective component of ProM also appears to contribute to poor ProM after TBI. When asked to request a questionnaire at the end of a session, prompting was beneficial for 10 out of 24 participants with TBI (Kinsella et al., 1996). By contrast, there was no disproportionate impairment of memory for the purpose of the questionnaire (retrospective component). More information about error type was provided by Shum et al. (1999) but this was limited to informal observations and the description of two error types. On event-based tasks, they reported a predominance of omission (vs. late responses) errors. These errors appeared to reflect ProM failures, as all participants could remember task instructions. Significantly more ProM failures by the participants with TBI than by control subjects were also reported by Mateer et al. (2000). However, when cues were detected, the TBI group was as able as groups of healthy younger and older adults to recall intended actions on time- and event-based ProM tasks. No significant differences were noted between controls and TBI participants in terms of task substitution (performing a novel action), loss of content (not remembering what to do), and repetition errors (repeating an action previously carried out).

Cue Distinctiveness and Prospective Remembering

One factor that has been shown to enhance the accuracy of event-based ProM
performance is cue distinctiveness. Its effect was first investigated in the context of retrospective memory research, where distinctiveness was defined either in terms of the set from which an item is drawn or in terms of the presentation context. The distinctiveness effect was explained in terms of an “incongruency” hypothesis where an event is incongruent with the meaning of information or with perceptual features of events contained in active working memory. As a result, greater attention is directed at the incongruent event (Schmidt, 1991). In retrospective memory, semantic distinctiveness is assumed to produce greater attention to an item than perceptual distinctiveness and to lead to better recall and recognition (Schmidt, 1985, 1991).

In ProM studies, the distinctiveness of a cue is usually determined in relation to the ongoing task (McDaniel & Einstein, 1993). A distinctive cue may be perceptually salient (e.g., upper-case font among low-case font, bold vs. normal-faced type, larger target-cue pictures vs. other pictures). Semantic distinctiveness is achieved by presenting cues that are unfamiliar in the context of a person’s knowledge (e.g., words in a foreign language, rare words) or familiar among unfamiliar items (Brandimonte & Passolunghi, 1994).

In the first ProM study involving perceptually salient cues, Brandimonte and Passolunghi (1994) focused on the effect of manipulations of target familiarity and distinctiveness. In one experiment, participants were presented with familiar or unfamiliar cues in the context of either all familiar or unfamiliar words, according to ratings of frequency of usage. Participants (n=128) were randomly assigned to one of four experimental conditions varying along the dimensions of familiarity and distinctiveness (e.g., a word familiar based on its usage and presented among unfamiliar items). A cue
was presented 8 times across 40 trials during a short-term memory task. The ProM response involved pressing any keyboard key. Results revealed that unfamiliarity and distinctiveness both facilitated ProM independently. In a second experiment, Brandimonte and Passolunghi (1994) manipulated perceptual distinctiveness by presenting the cues in upper- or lower-case letters among list items that were in lower-case letters. To eliminate the effect of semantic distinctiveness (Einstein & McDaniel, 1990; McDaniel & Einstein, 1993), familiar cues were introduced among familiar words, and unfamiliar cues among unfamiliar words. Students were randomly assigned to four conditions based on word familiarity and perceptual distinctiveness. The experiment revealed an effect of perceptual distinctiveness that was stable across trials and significantly stronger than the effect of semantic distinctiveness in the first experiment.

The effect of perceptual cue saliency has also been reported in samples of older adults. McDaniel et al. (1999) divided 41 older adults into four relatively equal groups according to their scores on two composite measures assessing either frontal or medial temporal lobe function. The frontal composite was derived from the WCST, the COWAT, Mental Arithmetic of the WAIS-R (Wechsler, 1981), and Mental Control and Backward Digit Span of the WMS-R. The temporal composite was based on selected subtests from the WMS-R and on the long-delay cued recall trial of the CVLT. The event-based ProM task was embedded in a general knowledge task and involved pressing a particular key in response to the cue. Saliency was manipulated by having the cue appear 4 times in boldface type and 4 times in a font indistinguishable from that employed for other words. Each participant was exposed to the two levels of saliency in a counterbalanced order.
Salient cues improved ProM performance by 39% across groups. Perceptually salient cues (bold versus normal-face type) also enhanced event-based ProM performance in another sample of older adults, who achieved an accuracy rate of 90% on a ProM task that made minimal demands on retrospective memory (McDaniel et al., 1997, as cited in Einstein et al., 2000). Results suggested that the intended action (pressing a key) was easily retrieved once the cue was noticed. Therefore, cue properties may be important in determining ProM performance.

Vogels et al. (2002) investigated age-related differences on four event-based ProM tasks differing along several dimensions. During a Word Comparison Task, participants indicated whether both words within a presented pair belonged to the same category by pressing one of two keys. Cues were defined as a pair where both words were printed in a different colour or in upper-case font. When the cues appeared, participants pressed a third key and withheld making a category judgement. Prospective lures were also included, where one word met partial criteria for the cue (printed in a different colour or font). On these trials, participants continued making category judgements. Although cues were salient, group differences were reported. However, it is not known if the performance of older adults was better than it would have been had the cues not been salient because cues were always salient. Furthermore, the authors commented that the complexity of task instructions may have contributed to the results by hindering the ability to maintain intentions in a highly activated state. Indeed, attention had to be paid to both the colour and the font of the words. Further, participants had to both make a different response (press a third key) and inhibit their response to the ongoing task when they
encountered the cues. The ProM task may therefore have placed a heavier load on both monitoring and inhibition processes compared to the tasks used in other studies manipulating cue saliency.

Perceptual cue saliency is assumed to lead to involuntary orienting and switching of attention toward the cue, whose significance as a retrieval cue would be highlighted and recognized, prompting its analysis (Brandimonte & Passolunghi, 1994; McDaniel & Einstein, 1993, McDaniel et al., 1997, as cited in Einstein et al., 2000). Thus, distinctiveness would trigger involuntary memory that something has to be done (the prospective component), which in turn would lead to a memory search for the intended action (Brandimonte & Passolunghi, 1994). Einstein et al. (1995) postulated that distinctive cues enhance ProM by facilitating cue recognition. The detection of salient cues would require less self-initiated monitoring and be less prone to disruption from other activities compared to the detection of non-salient cues (reviewed in McDaniel & Einstein, 2000). Indeed, the beneficial effect of distinctive cues on ProM performance compared to use of non-distinctive cues remains even under dual-task conditions (McDaniel et al., 1997, as cited in Einstein et al., 2000). Robustness of the effect has been interpreted to reflect the reliance of ProM on automatic rather than strategic processes under such circumstances (McDaniel & Einstein, 2000). Indeed, conditions that facilitate automatic retrieval render ProM unaffected by the degree of attentional resources devoted to the task (Kliegel et al., 2001).

According to a multiprocess framework developed by McDaniel and Einstein (2000) to demonstrate the complexity of ProM processes, cue distinctiveness is one of
several factors that may mediate the extent to which ProM tasks rely on automatic or strategic processes. McDaniel and Einstein postulated that the processes involved in ProM depend on numerous variables, including the nature of the cues (i.e., saliency), their relation to the intended action, the properties of the ongoing task, and individual differences. Some of the other variables that are thought to enable automatic processes include focal processing of the cue within the ongoing task, an ongoing task that is less engaging or demanding, and planning pertaining to the intended action. Research on older adults has shown that by reducing the reliance of event-based ProM tasks on strategic processes, and thus on self-initiation and deployment of attentional resources (Kliegel et al., 2001), minimal or no age-related decline in ProM is observed (see Einstein et al., 2000). Perceptual cue saliency has been found to enhance ProM performance in older adults, in whom the prospective component is more commonly impaired than the retrospective component (Cohen et al., 2001; West et al., 2002). Cherry and LeCompte (1999) have postulated that automatic activation of the cue-action link or automatic noticing of the cue underlies the positive effect of cue manipulations in older adults.

Implementation Intentions and the Completion of Intentions

The formation of an implementation intention refers to making an “if-then” plan (Gollwitzer et al., 2004). It involves the creation of an intent to “achieve goal-directed behaviour X when situation Y is encountered” (Gollwitzer & Brandstätter, 1997). For example, an implementation intention could be of the format “the first thing I will do when I arrive at work is tell my co-worker about my promotion” (Gollwitzer & Brandstätter, 1997). Forming such intentions is described by Gollwitzer (1993) as a
powerful self-regulatory tool allowing automatic initiation of a specified goal-directed behaviour under the control of predetermined environmental cues. It commits the person to carry out a specific goal-directed behaviour when the critical context is encountered. The effect of implementation intentions is reportedly present regardless of whether intentions are self-determined or induced by others (Gollwitzer & Brandstätter, 1997).

Two mechanisms are assumed to mediate the effect of implementation intentions on initiation of the intended action when the specified opportunity arises (Gollwitzer & Brandstätter, 1997). Gollwitzer’s (1993) theory postulates that by forming an implementation intention, the mental representation of a situation becomes highly activated. Consequently, the situation is easily accessed in memory. In turn, it should be spontaneously detected and readily attended to despite the complexity of a situation or involvement in another task when the specified situation arises (Gollwitzer et al., 2004). Forming an implementation intention also creates strong mental links between the specified goal-directed behaviour and the appropriate situation in which to carry out the action, allowing the specified context to automatically elicit the behaviour.

The type of automatic process underlying the effect of implementation intentions is termed strategic automaticity because a single conscious act of will is required to delegate control of goal-directed actions to specified and anticipated contextual cues rather than having the intended actions remain under conscious and effortful control (Gollwitzer & Schaal, 1998). Automatic action control is characterized by immediacy, efficiency, and a lack of conscious intent (Bargh, 1997). It is immediate because implementation intentions result in accelerated responding to the critical stimulus but are
not associated with a more general effect such as enhanced attention to the entire task. Efficiency refers to initiation of a goal-directed action regardless of the difficulty of a primary task in dual-task paradigms. The negative effects of heightened cognitive demands on initiation of goal-directed behaviours are reduced by forming implementation intentions because initiation of action relies on automatic processes (Gollwitzer, 1993, 1999). Efficiency also refers to the beneficial effects of implementation intentions for people with heightened distractibility and action control problems (Brandstätter et al., 2001).

Because they work by habitualizing, or making more automatic, the initiation of goal-directed actions, implementation intentions should be formed when difficulty with the implementation of goals is anticipated. Thus, the less automatic a behaviour, the more it should benefit from implementation intentions (Gollwitzer & Brandstätter, 1997). According to Brandstätter et al. (2001), the positive effect of implementation intentions may be most noteworthy in people who have problems with initiation or regulation of goal-directed behaviours. They may also be more beneficial for initiation of goal-directed actions pertaining to difficult versus easy goals (Gollwitzer & Brandstätter, 1997).

The beneficial effects of implementation intentions have been investigated in samples who have action control deficits, such as individuals with schizophrenia, frontal lobe injury, or withdrawal from opiates. The cognitive load under withdrawal conditions is thought to be high because individuals may be distracted by thoughts to ward off the urge (Gollwitzer, 1993). In a study by Brandstätter et al. (2001), 20 individuals who showed drug withdrawal symptoms and 21 individuals who no longer had symptoms of withdrawal
formed the intention of writing a curriculum vitae before 5 ProM. Half of the patients in each group were randomly assigned to forming implementation intentions specifying where and when they would write it. The other half formed irrelevant implementation intentions pertaining to when and where they would have lunch. By 5 ProM, completion rate was 0% for those who had formed irrelevant implementation intentions. Within the groups that had formed implementation intentions related to the task, the withdrawal group benefitted more (80% completion rate) than the post-withdrawal group (40% completion rate).

Patients with schizophrenia also have action control problems and difficulty filtering out irrelevant information (Watzl & Rist, 1997, as cited in Lengfelder & Gollwitzer, 2001). Twenty inpatients and 20 healthy controls were asked to press a button whenever a number appeared on the screen in a go/no-go task. The implementation intention instruction asked participants to increase their speed of responding whenever a "3" appeared. The familiarization instruction asked them to write down the number repeatedly to prepare for the task. Each participant performed the task under the two instructions, which were counterbalanced within each group. Although both conditions were effective in increasing speed of responding to the pre-specified number, performance under implementation intention conditions was superior for both patient and control groups. According to Brandstätter et al. (2001), the findings suggest that the effect of implementation intentions is robust to conditions of heightened cognitive demands, assuming patients have more distracting thoughts than controls.

Lengfelder and Gollwitzer (2001) also studied the effect of implementation
intentions in 20 patients with frontal lobe injury, 14 patients with non-frontal injury, and
33 healthy controls. Of the frontally-injured participants, 15 had sustained a TBI
compared to only four in the non-frontal group. Such individuals often show intact
automatic behaviour despite problems with the conscious control of actions (e.g.,
Cockburn, 1995; Lengfelder & Gollwitzer, 2001; Shallice, 1982). Although some
conscious reflection is involved in forming implementation intentions, the authors thought
that the group with frontal damage would benefit when helped to form implementation
intentions because action initiation relies on automatic processes. In a dual-task
paradigm, participants performed the go/no-go task described above, along with a tracking
task of variable difficulty. Results revealed a faster response rate to the specified context
(the number “3”) following the formation of implementation intentions than under
familiarization instructions, even when the tracking task was difficult. The most
prominent increase in reaction time under the implementation intention condition occurred
for patients with frontal injury. Within this group, faster reaction time was inversely
related to scores on the Tower of Hanoi, felt to measure the ability for conscious
deliberation and action control. According to Lengfelder and Gollwitzer (2001), their
findings provide evidence that implementation intentions are primarily based on automatic
processes. Furthermore, the enhanced benefit of implementation intentions for individuals
with action control problems implies that with normal brain functioning, continuous
conscious processing may occasionally dominate and interfere with automatic processes
(Lengfelder & Gollwitzer, 2001). Nevertheless, the results could also be a reflection of a
ceiling effect for the reaction time of the control and non-frontal groups.
In one of only two studies on the use of implementation intentions in the context of ProM, Chasteen et al. (2001) assessed its effect in older adults using two event-based ProM tasks. In the background pattern task, participants engaged in a working memory activity requiring a key press whenever a particular background pattern was seen. Although the second task was administered only after the background pattern task, its instructions were also given at the beginning of the session. Participants were asked to write the day of the week in the upper right hand corner of every sheet of paper received throughout the experiment (after completion of the first task). Each sheet of paper represented either a questionnaire or a neuropsychological test to be completed. For each ProM task, participants in the implementation intention condition were asked to visualize themselves performing the action and to describe the specific intention (e.g., “I intend to...”) for each ProM task. As expected, all participants performed significantly worse on the second task, which required more conscious processing due to the need for self-initiated retrieval and the lack of a salient cue. However, participants who formed an implementation intention were twice as successful (57% vs. 22%) in remembering to write the day of the week compared to subjects who had not formed a specific intention. Chasteen et al. (2001) hypothesized that forming implementation intentions automatically activated the intention to write the day of the week when participants were handed a sheet of paper. Another experiment with two additional control groups showed that this was not due to greater specificity of instruction regarding the day of the week nor to having more time (45 s) to think about or rehearse the task. By contrast, formation of implementation intentions failed to improve either accuracy or speed of responding on the background
pattern task. The failure of implementation intentions to enhance ProM under this condition may be due to the fact that the cue was focal to the ongoing activity and involved recognition rather than self-initiated retrieval. Consequently, the ProM task may have relied on more automatic processes.

In another ProM study, Einstein et al. (2003) failed to find a beneficial effect of implementation intentions when requiring healthy participants (n=20) to postpone an intended action. However, their power to detect a medium effect size was only .39. In addition, their paradigm was highly complex and required withholding a ProM response to a red screen until completion of an ongoing task 5 to 40 s later, which was sometimes interrupted by the introduction of a new task. Participants in the implementation intention condition had 6 s only to form such an intention during appearance of the red screen and the instructions were different from those used in other studies. Einstein et al. (2003) asked participants to visualize the task change and imagine themselves performing the response immediately after, with the phrase “task change/press slash key” appearing on the red screen. This involved more imagery and thus not necessarily a self-statement of intention. Another issue concerns the ambiguity of the cue because the red screen can be viewed as a cue to form an implementation intention in order to perform the ProM response whereas task completion served as a cue to actually carry out the response. The authors suggested that implementation intentions may be most beneficial when there is an emphasis on recall rather than recognition of cues. Furthermore, they claimed that participants may also need to have specific and concrete cues for responding (e.g., receiving a sheet of paper) rather than cues defined more vaguely as the beginning or the
end of an activity.

Although few studies have discussed the impact of implementation intentions on prospective remembering, the two domains of research are similar (Gollwitzer & Brandstätter, 1997). Implementation intentions link an anticipated future situation to a certain goal-directed behaviour in order for that behaviour to be carried out when the future situation arises (Gollwitzer & Brandstätter, 1997). Similarly, ProM tasks require that an association between the cue and the intended action be formed in memory and that the person remember to perform the action when the cue occurs (Einstein & McDaniel, 1990). Implementation intention studies cite two reasons why initiation of goal-directed behaviours may fail in the absence of implementation intentions, namely (1) failing to notice the appropriate moment to act or (2) noticing too late because attention is directed elsewhere, such as due to fatigue, depression, or absorption in another activity (Gollwitzer & Brandstätter, 1997). This resembles Schacter's (1999) statement that ProM failures may arise because of absentmindedness when the intended action must be carried out. Omissions, fluctuating performance, and late responses have been reported on ProM tasks. Schacter (1999) also attributed omissions to failure to specify contextual cues ahead of time. If that is the case, forming implementation intentions may indeed enhance prospective remembering.

Rationale for the Current Study

Most studies investigating ProM performance in TBI have aimed to determine whether performance is negatively impacted by the brain injury and whether the effect is similar across ProM tasks. Overall, studies of individuals with severe TBI have shown
reduced ProM on time-and event-based tasks compared to healthy controls using a variety of methods (Groot et al., 2002; Kopp & Thöne-Otto, 2003; Shum et al., 1999). However, no published study has investigated whether event-based ProM deficits reported in groups with severe TBI extend to a sample of individuals with milder levels of injury.

It is also unknown whether there are conditions that may benefit prospective remembering in individuals with TBI. In a study by Groot et al. (2002), brain-injured individuals who took notes performed better than those who did not, although their performance remained lower than that of controls. Because taking notes was based on personal preference rather than on random assignment, enhanced ProM performance may be due to a factor other than note-taking. The impact of individual differences or differences in rehabilitation cannot be ruled out. Sohlberg et al. (1992) investigated the effects of ProM training in two individuals with TBI. Training consisted of repeatedly administering time-based ProM tasks that were to be performed at increasingly longer time intervals. Both individuals were able to increase the length of time between task instruction and successful ProM performance over the course of training. However, training was extensive, requiring 32 sessions for one individual and 58 sessions for another over the course of 3 to 5 months. Furthermore, the study was of a descriptive nature, making the reason for improvement unclear.

In other samples of cognitively vulnerable individuals, namely older adults and people with focal frontal lobe lesions, perceptual cue distinctiveness and the formation of implementation intentions have demonstrated beneficial effects on prospective remembering (e.g., Chasteen et al., 2001; Lengfelder & Gollwitzer, 2001), which are
thought to stem from their reliance on automatic processes (Gollwitzer & Brandstätter, 1997; McDaniel & Einstein, 2000).

Intact automatic processes are reported in individuals with frontal injury despite deficits in controlled processes (Lengfelder & Gollwitzer, 2001). Because injury to frontal regions is commonly incurred by individuals with TBI (Kraus & Levin, 2001), they may show a similar pattern of differential impairment of strategic and automatic processes. Individuals with severe closed head injury have consistently shown deficits relative to healthy controls on tests of explicit recall requiring conscious retrieval of information, with preserved performance on perceptual implicit memory tests that emphasize automatic processing (e.g., Schmitter-Edgecombe, 1996). A recent study by Schmitter-Edgecombe and Nissley (2000) isolated automatic and controlled components of memory within a single task with strong reliance on perceptually driven processes. They demonstrated intact automatic processing in a sample of 24 individuals with severe TBI assessed at least one year post-injury, even when attention at encoding was divided between two tasks. By contrast, consciously controlled processes were impaired relative to 24 controls even under full attentional conditions at encoding.

In clinical practice, several mnemonic strategies designed to help individuals with TBI are based on spared nondeclarative memory, a type of memory that does not rely on conscious awareness of learning (Squire, 1994). Like habits, implementation intentions elicit immediate and efficient behaviour in the presence of a particular situation. However, compared to the frequent and consistent pairings of situation-action that underlie the automaticity of habits, a single conscious mental act is needed to transfer
control of the intended action to a specific environmental cue with implementation intentions. On the other hand, various mechanisms have been hypothesized to mediate the effect of cue distinctiveness on ProM but they share the common feature of reduced reliance on strategic processes, with involuntary attention to the cue, facilitating its recognition as a retrieval cue, and minimal emphasis on self-initiated monitoring.

The effects of cue distinctiveness and implementation intentions on ProM have not been investigated in samples with TBI. Identifying variables associated with better event-based ProM in TBI has practical implications because such variables could provide another way (besides the use of external aids) to enhance prospective remembering in individuals with TBI and thus promote their independence. Current memory aids are helpful predominantly for time-based tasks, are often expensive, and sometimes require involvement of a significant other (Thöne-Otto & Walther, 2003).

Another area that has been under-investigated in the ProM literature concerns the systematic analysis of the kinds of errors made by individuals with TBI on event-based ProM tasks. Although the relative contribution of the prospective and retrospective components to ProM decline has been well-investigated in older adults (e.g., Cohen et al., 2001), along with detailed error analysis (Friesen, 1999), this has not been the case in samples with TBI. Knowing why persons with TBI have difficulty successfully carrying out their intentions at the appropriate moment is important in order to design ProM aids that aim to limit such errors and to make environmental modifications to prevent their occurrence. It also may provide insight into the mechanism underlying ProM performance in people with TBI.
Goals and Hypotheses

Hypothesis 1

One of the main objectives of this study was to compare the ProM performance of the TBI group to that of a group of healthy adults using two event-based ProM tasks, namely the Navigating Your Week (NYW) game and the Prospective Remembering of Actions and Sentences (PROAS) task. The group with TBI was expected to score significantly below the control group on both ProM tasks because (1) ProM complaints are common in clinical work with this population and (2) objective ProM impairments have been documented in individuals with severe TBI (e.g., Shum et al., 1999).

Hypothesis 2

Another major purpose of the study was to evaluate the types of errors made by the group with TBI on the two event-based tasks. Errors were classified into several categories based on prior research. Given findings reported in an unpublished study by Mateer et al. (2000), ProM failures (omissions) were expected to be the predominant type of error made by subjects with TBI. No differences were anticipated between the other error types.

Hypotheses 3 and 4

Two other aims of this study were to investigate whether perceptual cue saliency (environmental manipulation) and formation of implementation intentions (internal strategy) enhance prospective remembering on event-based ProM tasks in a group of individuals with mild to moderate TBI. The relative preservation of automatic processes following TBI suggests that experimental conditions relying on these processes may
enhance prospective remembering. It was therefore predicted that event-based ProM performance by the TBI group would be significantly better in the presence of perceptually distinctive cues compared to their performance under non-salient cue conditions, although scores would likely remain below those of the control group. Similarly, it was hypothesized that the group with TBI would obtain higher scores on event-based ProM tasks when forming implementation intentions compared to their performance after listening to a description of the intention to be performed or after telling the examiner the action to be performed.

Hypothesis 5

The Rey Auditory Verbal Learning Test (RAVLT; Rey, 1964) was administered as a measure of retrospective memory to establish construct validity for the ProM tasks. A small to medium positive correlation was anticipated between the scores obtained by participants with TBI on the RAVLT and on each ProM test because of the association between retrospective memory and ProM in other samples with TBI (e.g., Groot et al., 2002). Furthermore, the ProM tasks employed in the current study placed a relatively high load on retrospective memory by requiring participants to remember several cues and intentions. Scores obtained by TBI participants on ProM tasks were also predicted to be related to their performance on cued recall measures.

Hypothesis 6

A self-report questionnaire (the Prospective and Retrospective Memory Questionnaire or PRMQ; Smith et al., 2000) pertaining to everyday failures of prospective and retrospective memory was administered to all participants to evaluate the link between
subjective ProM functioning and objective event-based ProM performance. This measure was included in the study given its brevity and the importance of the information it could yield regardless of its relationship with objective ProM performance. Despite the frequent lack of a relationship between self-reported and objective ProM task performance in people with severe TBI, a relationship between the ProM subscale of the PRMQ and performance on both ProM tasks was anticipated because the ProM subscale taps ProM failures to a greater extent that do other self-report measures used in studies of ProM in TBI samples. Furthermore, the sample of TBI participants was assessed at least 6 months post-injury and previous studies have suggested that memory may be more likely to be perceived accurately as the time since injury increases (e.g., Allen & Ruff, 1990; Sbordone et al., 1998).
Method

Participants

Recruitment

The final sample consisted of 20 individuals who sustained a TBI and 20 healthy adults, ranging in age from 21 to 55. Women outnumbered men by a 4:3 ratio in each group (12 women: 8 men). Almost a third of community-dwelling adults with TBI were recruited through advertisements posted in the outpatient neuro-treatment unit of the Gorge Road Hospital in Victoria, British Columbia. Several participants with and without TBI were informed of the study through advertisements posted in a laboratory at the University of Victoria where an unrelated study was being run by a different investigator. There were also many respondents to advertisements posted in academic departments at the University of Victoria, in the local newspaper, and in a computer newsgroup aimed at the general population of the Victoria area. A few individuals were recruited through other participants. All people interested in participating in the current research initiated contact with the investigator. They were compensated with $40.00 for their participation.

TBI Group

To be included in the study, people with TBI had to be at least 6 months post-injury, given that most of the spontaneous recovery occurs between 3 and 6 months post-injury (Lezak, 2004) and that participants in other ProM studies were often evaluated more than 6 months post-TBI (Groot et al., 2002; Kinsella et al., 1996). Furthermore, the injury had to have occurred after the age of 16 to avoid potentially confounding effects due to ongoing brain maturation that tapers off starting in late adolescence (e.g.,
Huttenlocher, 1984). Medical consultation for TBI-related issues had to have been sought within 24-hours post-injury to prevent the inclusion of individuals with very mild or questionable injuries. Initially, the study proposed to focus solely on individuals with mild to moderate TBI because the majority of existing studies pertain to severe injury. However, due to the very slow rate of recruitment, the inclusion criteria were eventually broadened to include individuals with more severe injury.

The severity of the TBI was classified based on participants’ self-report of commonly used criteria established by the American Congress of Rehabilitation Medicine and by Lezak (1995), including depth of coma measured by the Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974), self-reported duration of post-traumatic amnesia (PTA), and length of loss of consciousness (see Table 1).

<table>
<thead>
<tr>
<th>TBI severity</th>
<th>GCS score</th>
<th>Length of unconsciousness</th>
<th>Duration of PTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>13-15</td>
<td>30 min or less&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&lt; 1 hour</td>
</tr>
<tr>
<td>Moderate</td>
<td>9-12</td>
<td>&lt; 6 hours</td>
<td>1-24 hours</td>
</tr>
<tr>
<td>Severe</td>
<td>8 or less</td>
<td>&gt; 6 hours</td>
<td>&gt; 24 hours</td>
</tr>
</tbody>
</table>

<sup>Note</sup>. GCS = Glasgow Coma Scale; PTA = post-traumatic amnesia.

Whenever the various criteria did not allow for a convergent rating of the severity of brain injury (e.g., PTA < 1 hour and loss of consciousness > 6 hours), the severity was determined based on the length of loss of consciousness. The only exception to this was in 2 cases where an objective report of the GCS was available. For most TBI participants,
length of loss of consciousness was the primary index of severity due to the unreliability of self-reports of PTA (Goldstein & Levin, 1995; Gronwall & Wrightson, 1980). Furthermore, several participants reported having difficulty remembering when this period of confusion ended.

For descriptive purposes, participants were also asked whether they had suffered a skull fracture and whether neuroimaging data (a CT scan of the head) had yielded positive results. The results of the CT scan were reported to be positive by 9 of the 18 individuals who had such a scan. Seven participants with TBI did not know their results (n=7). Medical documentation was only obtained from the 6 individuals who possessed such records; documentation was not requested to confirm the other participants’ self-report due to practical reasons (i.e., cost and time involved to request documentation from family physicians). Exclusion criteria included a history of neurological disturbance or severe vision or hearing-related difficulties that could interfere with successful task completion, and significant sensory/motor dysfunction precluding the ability to write with the dominant hand. Participants were also screened for colour blindness given an experimental manipulation based on the colour of stimuli. A history of substance abuse, psychiatric illness, or both did not serve as exclusion criteria. Given the high prevalence of these problems in individuals who sustain a TBI (Seel & Kreutzer, 2003; Taylor et al., 2003), excluding participants on these bases would not have been representative of the characteristics of the population of interest and would have reduced the generalizability of the conclusions of the study. Individuals who were older than 55 years of age were excluded to minimize potentially confounding effects due to age-related cognitive decline.
Twenty-seven individuals with TBI were screened during a brief telephone intake. Three of them were not accepted into the study because they had suffered a stroke. The data from 4 of the remaining 24 participants was discarded for the following reasons: 3 individuals were unable to understand the instructions for one or both of the ProM tasks and one subject revealed having non-TBI related neurological symptoms that were under investigation.

The following description of the sample pertains only to the 20 individuals whose data was analyzed. Injury-related characteristics are presented in Table 2. Mean time post-injury was 7.21 years \( (SD = 1.30 \text{ years}) \), with a range of 9.73 months to 19.84 years. Nineteen participants were seen at a hospital for TBI-related injuries; 12 were admitted. The mean length of hospital stay was 65.25 days \( (SD = 98.02) \), and ranged from 0 (no hospitalization) to 300 days. Most participants with TBI had received some form of rehabilitation beyond physiotherapy. The mean total score on the Postconcussion Syndrome Checklist (PCSC; Gouvier et al., 1992), a 10-item checklist of post-concussion symptoms, was 72.35 \( (SD = 24.71) \). Individuals endorsed between 1 and 10 items, with a mean of 6.70 \( (SD = 2.74) \). Problems with memory \((n=20)\), concentration \((n=19)\), and fatigue \((n=17)\) were most frequently rated as occurring at least “seldom.” On average, fatigue was rated as being “vaguely present” to “clearly present” \( (M = 2.65, SD = 1.09) \). Nineteen individuals with TBI were employed or attending school at the time of their injury.
Table 2. Frequency of TBI-related characteristics.

<table>
<thead>
<tr>
<th>Injury-related characteristics</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etiology</td>
<td></td>
</tr>
<tr>
<td>Motor vehicle collision</td>
<td>12</td>
</tr>
<tr>
<td>Bicycle collision</td>
<td>4</td>
</tr>
<tr>
<td>Assault or fall</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
<tr>
<td>Severity</td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>10</td>
</tr>
<tr>
<td>Moderate</td>
<td>0</td>
</tr>
<tr>
<td>Severe</td>
<td>10</td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td>17</td>
</tr>
<tr>
<td>Skull fracture</td>
<td>7</td>
</tr>
<tr>
<td>Hospital-based rehabilitation services</td>
<td>17</td>
</tr>
<tr>
<td>ABI program</td>
<td>8</td>
</tr>
<tr>
<td>Litigation</td>
<td>3</td>
</tr>
<tr>
<td>Previous TBI</td>
<td>4</td>
</tr>
</tbody>
</table>

Note. ABI Program = Acquired Brain Injury Program at the Gorge Road Hospital, Victoria, BC. This is a structured rehabilitation program involving occupational therapy, speech therapy, physiotherapy, and cognitive rehabilitation groups.

Control Group

The control group was matched to the TBI group for gender, age, and years of education on a case-by-case basis. A discrepancy of up to 2 years was accepted for years of education and up to 5 years for age between matched cases. Exclusionary criteria were identical to those for the TBI group. Twenty-five control subjects were screened by telephone. One person was not accepted in the study because he was undergoing tests for a potential neurological condition. Four other people participated in the study but their data was discarded for the following reasons: one subject did not understand the instructions for one of the ProM tasks, two participants did not match to any of the
individuals in the TBI group after the exclusion of some of the TBI participants' data from the analyses, and one French-speaking participant was not fluent enough in English to comprehend all of the instructions and the stimuli presented.

Table 3 lists the demographic characteristics of the groups. It reveals that the mean age, years of education, level of pain on the day of testing, and scores on the North American Adult Reading Test (NAART; Blair & Spreen, 1989), CAGE alcohol, and CAGE drug use did not differ significantly between the groups based on separate two-tailed independent-samples t-tests ($p > .05$). The number of individuals who endorsed at least one item on the CAGE alcohol measure was comparable across groups (TBI: $n = 8$, NC: $n = 10$), as was the number of people within each group who answered positively to one or more items on the CAGE drug use measure ($n=6$ for both groups). By contrast, the TBI group had significantly higher scores on measures of psychological distress, namely the Beck Anxiety Inventory (BAI; Beck & Steer, 1990) (using a Mann-Whitney test due to non-normality of the data) and the Beck Depression Inventory-II (BDI-II; Beck et al., 1996). On the BDI-II, the three items most frequently endorsed by the TBI group were problems with fatigue (85%), concentration (75%), and decision-making (75%).
Table 3. Participant demographics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>TBI</th>
<th></th>
<th>NC</th>
<th></th>
<th>t (1, 38)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>38.1</td>
<td>10.39</td>
<td>38.55</td>
<td>11.27</td>
<td>-0.13</td>
</tr>
<tr>
<td>Education</td>
<td>15.5</td>
<td>3.65</td>
<td>15.33</td>
<td>2.55</td>
<td>0.18</td>
</tr>
<tr>
<td>NAART</td>
<td>25.4</td>
<td>10.72</td>
<td>19.8</td>
<td>7.73</td>
<td>1.89</td>
</tr>
<tr>
<td>Pain level(^a)</td>
<td>2.45</td>
<td>2.56</td>
<td>1.95</td>
<td>2.44</td>
<td>0.63</td>
</tr>
<tr>
<td>CAGE</td>
<td>0.95</td>
<td>1.36</td>
<td>0.95</td>
<td>1.05</td>
<td>0</td>
</tr>
<tr>
<td>CAGE (drugs)</td>
<td>0.55</td>
<td>1.05</td>
<td>0.55</td>
<td>1.05</td>
<td>0</td>
</tr>
<tr>
<td>BAI</td>
<td>13.85</td>
<td>10.21</td>
<td>6.15</td>
<td>6.45</td>
<td>((^b)97.5)**</td>
</tr>
<tr>
<td>BDI-II</td>
<td>18.25</td>
<td>10.11</td>
<td>7.8</td>
<td>6.22</td>
<td>3.94**</td>
</tr>
</tbody>
</table>

Note. BAI = Beck Anxiety Inventory; BDI-II = Beck Depression Inventory-II; NAART = North American Adult Reading Test.  
\(^a\) Participants rated their level of pain on a 0-10 scale, where 0 corresponded to the absence of pain and 10 signified the highest level of pain ever experienced.  
\(^b\) Mann-Whitney test.  
**p < .01.

The frequency of various demographic and health-related variables in each group is outlined in Table 4. Chi-square analyses revealed that there were significantly more TBI than control participants on psychoactive medications. Two TBI participants were on antipsychotic medications, 5 were on anticonvulsants, and 8 took antidepressants. The groups did not differ in terms of consumption of alcohol, current occupational or educational status, psychiatric history, ethnicity, or language (p > .05). The three controls who reported English to be their second language learned the language in childhood. Regarding ethnicity, participants were primarily of Caucasian origin except for three individuals with TBI: one was Native Canadian and two reported a mixed ethnicity.
Table 4. Frequency of demographic and health variables per group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>English as a second language</td>
<td>0</td>
</tr>
<tr>
<td>Employed or attending school</td>
<td>8</td>
</tr>
<tr>
<td>Alcohol use</td>
<td>10</td>
</tr>
<tr>
<td>Drug use</td>
<td>2</td>
</tr>
<tr>
<td>Psychiatric history</td>
<td>9</td>
</tr>
<tr>
<td>Use of psychoactive medications</td>
<td>11</td>
</tr>
<tr>
<td>Diagnosis of learning disability</td>
<td>0</td>
</tr>
<tr>
<td>History of learning problems</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>NC</td>
</tr>
</tbody>
</table>

Measures

Questionnaires for Demographics and Injury-Related Variables

During the initial telephone contact with participants, basic demographic and health-related information was gathered for screening and descriptive purposes. The Demographics Screener is presented in Appendix B. Additional demographic- and health-related information was collected during the testing session (see Appendix C). The Demographics Questionnaire served as a filler activity during a ProM task. Injury-related information was obtained over the telephone when screening individuals with TBI (see Appendix D).

CAGE

The CAGE (Cut down, Annoyed, Guilty, Eye opener; Ewing, 1984) is a very brief
questionnaire designed to screen for alcohol abuse. Its questions were modified to also assess for drug abuse. It consists of four questions to be answered yes or no based on the lifetime use of alcohol and drugs. A higher score out of a total of 4 points indicates a more significant problem with alcohol or drug use.

**Beck Depression Inventory (BDI-II)**

Given the high prevalence of depression following TBI (Kennedy et al., 2005; Rapoport et al., 2005), a self-report measure of depression was administered. The BDI-II (Beck et al., 1996) is a 21-item self-report measure to assess cognitive, affective, and vegetative symptoms of depression. Responses are made on a 4-point, minimally anchored scale based on symptoms experienced during the previous 2 weeks. The BDI-II yields a total score out of 63, with higher rates of endorsement reflecting a greater degree of distress (e.g., 0-13 = minimal; 14-19 = mild; 20-28 = moderate; 29-63 = severe).

Although some of the items overlap with TBI sequelae (Babin, 2003), the BDI-II was selected because it is a well-known and well-researched measure of depressive symptomatology that was revised to more closely correspond with DSM-IV criteria for major depressive disorder (Strauss et al., 2006) and that has well-established psychometric properties that are reviewed in Strauss et al. (2006). For example, it has shown good convergent validity with other depression-related instruments (e.g., SCID-I, r = .83, Sprinkle et al., 2002; Hamilton Psychiatric Rating Scale for Depression, r = .71, Beck et al., 1996). Furthermore, it has been employed in previous studies on TBI (e.g., Glenn et al., 2001), allowing the level of symptomatology in the current study to be compared with the extent of symptoms in other TBI samples.
Beck Anxiety Inventory (BAI)

This 21-item self-report of anxiety (Beck & Steer, 1990) was given because 20-30% of individuals report symptoms of anxiety post-TBI based on a review by Moore et al. (2006). This particular scale was selected for its brevity and because it was developed by the authors of the depression scale (BDI-II) chosen for this study. The BAI was developed to assess for anxiety without the confounds of depression. It measures the severity (frequency) of anxiety symptoms, including somatic, cognitive, and behavioural manifestations. Items are rated on a 4-point, minimally anchored scale based on how individuals have felt in the past week. The scale yields a total score out of 63, with higher rates of endorsement reflecting greater symptomatology (e.g., 0-7 = minimal; 8-15 = mild; 16-25 = moderate; 26-63 = severe). It is among the most commonly used measures of anxiety for research purposes (Piotrowski, 1999).

Postconcussion Syndrome Checklist (PCSC)

To evaluate the extent to which TBI participants continue to report symptoms of the post-concussion syndrome, the PCSC was used (Gouvier et al., 1992; see Appendix F). On this 10-item checklist, participants with TBI rated the frequency, intensity, and duration of cognitive, physical, and affective symptoms most commonly related to the post-concussion syndrome. Ratings were made on a 5-point Likert scale based on the last 24-hour period, consistent with the administration guidelines provided by Gouvier et al. (1992). The sum of all ratings yielded a total score out of 150.

Prospective and Retrospective Memory Questionnaire (PRMQ)

Because of its brevity and its association with performance on tests of prospective,
but not retrospective, memory in a study of healthy adults (Mäntylä, 2003), the PRMQ was chosen to assess whether self-reported ProM functioning is consistent with performance on ProM tasks. This 16-item memory self-report (see Appendix E) was designed to measure failures of prospective and retrospective memory in everyday life (Smith et al., 2000). Half of the items assess ProM failures. Each item can be categorized along three dimensions, namely in terms of the type of failure, whether failures occur in the context of self-cuing (time cue) or environmental cuing (associative cue), and whether items involve short- or long-term remembering. Items are rated on a five-point Likert scale according to frequency of memory failure. Each subscale is scored out of 40 points.

Psychometric properties and normative data based on a large (n=551) community sample ranging in age from 17 to 94 are presented in Crawford et al. (2003). A confirmatory factor analysis revealed that all items share a general memory factor in addition to orthogonal dimensions specific to ProM or retrospective memory. Internal consistency using Cronbach’s alpha was .89 for the total scale, .84 for the ProM subscale, and .80 for the retrospective memory subscale. In a validation study of the PRMQ, Mäntylä (2003) divided 200 middle-aged adults from the community into self-reporters and non-reporters of ProM or retrospective memory problems based on their answers on the PRMQ. The ProM subscale showed larger differences between the two groups than the retrospective memory subscale. Self-ratings of either prospective or retrospective memory failures on the PRMQ were associated with lower scores on ProM tasks.

North American Adult Reading Test (NAART)

The NAART (Blair & Spreen, 1989) is a measure of adult reading used to estimate
premorbid intellectual ability. Participants read aloud a list of 61 irregularly spelled words. The total number of errors was tabulated based on incorrectly pronounced words.

Psychometric properties, such as the NAART’s high test-retest and inter-rater reliability, are summarized in Strauss et al. (2006). Moderate to high correlations (.4 to .8) are reported between performance on the NAART and general intellectual skills. The NAART was selected because it is reported to be resistant to neurological disturbances, including TBI (Crawford et al., 1988; Watt & O’Carroll, 1999). Although a decline in reading skills may occur with a severe TBI (Riley & Simmonds, 2003), the NAART may not be as susceptible to brain injury as other cognitive measures (see Strauss et al., 2006).

**Digit Span Backward**

This brief measure of working memory (derived from the Wechsler Adult Intelligence Scale-III, The Psychological Corporation, 1997) was added to allow for comment on the status of attention because of the high frequency of attention deficits after TBI (Ríos et al., 2004; Serino et al., 2006). Furthermore, working memory has been speculated to play a role in ProM functioning (Kliegel et al., 2000; Schmitter-Edgecombe & Wright, 2004). Participants were required to memorize progressively longer sequences of digits (ranging from 2 to 8) and to repeat them in the reverse order. There were two sequences corresponding to each string length. As per the standard administration, the test was discontinued after failure on both sequences containing an identical number of digits. The total number of items correctly answered yielded a score out of 14.

**Rey Auditory Verbal Learning Test (RAVLT)**

The RAVLT (Rey, 1964) is a measure of verbal learning and memory. A list of 15
unrelated nouns was read aloud, after which participants were asked to recall as many items as possible in any order. The list was presented in an invariant order during five consecutive trials. After the fifth trial, a list of 15 new nouns was read, followed by a free recall trial for this new list. Participants were then asked to recall the words from the previous list, without first hearing them. After a 20-minute delay, they were asked to provide the words from the first list. The scores of interest for this study were those obtained on Trial 1 (immediate recall), List B (immediate recall), and Trial 7 (delayed recall).

Due to their high correlation ($r = .43, p = .005$), the scores on Trial 1 and List B were combined to reduce the Type 1 error. To form a single “immediate recall” score out of 15, the mean score obtained across the two trials was calculated (i.e., summing the Trial 1 and List B scores for all subjects and dividing the total by 2). The RAVLT correlates moderately well with other tests of learning and memory (e.g., Stallings et al., 1995).

**Navigating Your Week (NYW) Game**

This board game, played alone, was modeled after Rendell and Craik’s (2000) Virtual Week game, developed as a ProM task that would closely approximate everyday ProM activities in their study with older adults. Similarly, the NYW game simulated having to juggle multiple, simultaneous intentions over the course of a week, which more closely resembles everyday demands compared to repeated presentation of a single cue during computer tasks (Kliegel et al., 2000). Furthermore, as in daily life, a variety of intentions had to be formed. The layout and process of the NYW game, as developed by Rendell and Craik (2000), were modified for the purposes of the study (e.g., event-based
ProM tasks only) and to address what were viewed as task weaknesses (e.g., a test of content recall was added).

The NYW game required participants to remember to tell the examiner what lifelike activities they had to “carry out” when relevant cues were presented. It was played using dice, a game piece, 54 index cards (12.7cm x 7.6cm) for each of the two versions of the task, and a laminated bristol board (67cm x 54cm) representing one day of the week. Additional test materials included a stopwatch, a package of filler activities, and a test form. Figure 1 shows the layout of the board.

**Figure 1.** Navigating Your Week game layout.
Times of the day (from 8am to 7pm) were marked on 12 of the 100 squares to simulate a real day. A picture of a card, printed on 9 evenly spaced squares, indicated that a card had to be picked up. A task summary (not shown) was glued to the board.

During the task instructions, each type of card was introduced and explained. Nine sample items were then given and clarifications were provided as needed. The task was administered only after a participant could successfully complete the sample items. To start the NYW game, participants picked up a card introducing a cue and an action to be remembered and read it aloud. The card was one of three types that could be picked up throughout the game. A description of each type of card and of the response required upon its presentation is listed in Table 5.

Table 5. Card types and their associated responses in the NYW game.

<table>
<thead>
<tr>
<th>Card</th>
<th>Description</th>
<th>Response required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cue introduction</td>
<td>Describes a task to be performed later that day (2 per day) or the next day (1 per day) in the form of “I have to...” Introduces the cue and describes the intended task, with three options pertaining to the task. Participants were informed that they did not have to remember their choice.</td>
<td>Make a choice aloud. Example: choose whether to pick up pants, a jacket, or a sweater at the dry-cleaners on the next shopping trip.</td>
</tr>
<tr>
<td>Cue reinstatement</td>
<td>Presents the word cue to perform the prospective memory task (e.g., shopping) but the cue is embedded in the context of another activity (e.g., shopping for shoes).</td>
<td>Mention the activity that needs to be carried out. Inform the examiner even if late and say that they have to do something even if they do not remember what.</td>
</tr>
<tr>
<td>Prospective memory lure</td>
<td>Describes other activities relevant to the time of day.</td>
<td>No response.</td>
</tr>
</tbody>
</table>
Each day, participants picked up 3 cards of each type, for a total of 9 cards per day. The cards were presented in an order designed to be coherent and plausible given the time of day. Examples of each type of card are presented in Figure 2.

**Figure 2.** Card examples for the NYW game.

- I have to buy milk when I go to the grocery store tomorrow. I need milk to make:
  - a) pancakes
  - b) chocolate pie
  - c) muffins

  **Cue introduction**

- I go to the grocery store to get some bread.

  **Cue reinstatement**

- I sit at my computer to read the newspaper online.

  **PM lure**

During the NYW game, participants rolled the dice to move their token around the board, which they circled 6 times to represent 6 days of the week. Whenever participants passed or landed on a picture of a card, they picked up a card. They read the card aloud and then turned it over, before engaging in a non-verbal filler task for 20 seconds to
prevent rehearsal of the cue and of the intended action. The filler activities were cancellation tasks that required participants to cross out various symbols and letters as quickly and as accurately as possible, and basic written math. After 20 seconds, participants returned to the game by rolling the dice. Therefore, they alternated between rolling the dice (and reading a card, if appropriate) and engaging in filler tasks. Administration time was about 50 minutes.

There were two versions of the NYW game. The versions were comprised of identical items; however, the saliency of each cue on cue reinstatement cards varied depending on the test version. For each version, half of the cues were salient (i.e., the cue words were printed in red upper-case font) during cue reinstatement and interspersed with cue reinstatement cards containing non-salient cues. The version of the NYW game administered was counterbalanced within each group to ensure that saliency was not confounded with item difficulty. Therefore, the nine cues that were salient for half of a group were not salient for the remainder of the group. The version of the NYW game was randomly assigned to participants.

Verbatim responses were recorded. The ProM score consisted of the number of intentions correctly recalled out of 18. To be scored as correct, the appropriate response had to be made prior to presentation of the next cue. If participants remembered that they had to carry out a response but were unsure of its content, they were asked to say so. The total score was converted into a percentage correct score (i.e., number of correctly recalled items divided by 18) to allow for comparison with scores obtained on the PROAS. Errors were divided into 6 categories, as described in Table 6. The frequency of each type of
error was tabulated. The proportion of each type of error out of all errors committed was also calculated to identify the frequency of each type of error within each group.

The inter-rater reliability of the NYW game was established by obtaining a reliability correlation coefficient through re-scoring of all items for which participants did not provide verbatim reproductions of the correct answers by an independent rater who was unfamiliar with the group membership of participants. A Cohen’s Kappa statistic indicated high (97%) inter-rater agreement. Internal consistency, calculated using Cronbach’s alpha, was 86%. The validity of the NYW game will be addressed in the Results section.

Table 6. Classification of error types for the NYW game.

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProM failure</td>
<td>Failure to respond when the cue was presented (response omission).</td>
</tr>
<tr>
<td>Novel response</td>
<td>Response that was not associated with any previously presented or upcoming</td>
</tr>
<tr>
<td></td>
<td>cues (e.g., response associated with the multiple choice content of a cue</td>
</tr>
<tr>
<td></td>
<td>introduction card).</td>
</tr>
<tr>
<td>Task substitution</td>
<td>Response that was associated with another cue.</td>
</tr>
<tr>
<td>Repetition</td>
<td>Response that was already given.</td>
</tr>
<tr>
<td>Loss of content</td>
<td>“I don’t remember what to do” response.</td>
</tr>
<tr>
<td>Approximation</td>
<td>Response that was partly accurate for either the action or the object (e.g.,</td>
</tr>
<tr>
<td></td>
<td>”I have to ask my friend for tickets” rather than “I have to give my friend</td>
</tr>
<tr>
<td></td>
<td>some tickets).</td>
</tr>
</tbody>
</table>

*Note.* ProM = prospective memory.

Cued Recall Measure for the NYW Game

Cued recall can indicate that someone remembered an intention despite not responding to the cue during the task (Cohen, 1999). To assess this possibility, a cued
recall test was administered at the end of the NYW game. Half of the items assessed recall of the cue associated with each intended action and half assessed recall of intended actions. The percentage of the 18 items correctly remembered was calculated.

*Prospective Remembering of Actions and Sentences (PROAS)*

The format of this task, namely to provide a verbal (e.g., ask for the time) or action (e.g., change pens) response to cues, was modeled after ProM tasks developed by Raskin and Buckheit (1998), Mateer et al. (2000), and Groot et al. (2002). The PROAS was comprised of 15 event-based ProM tasks to be carried out within about 50 minutes while participants engaged in filler activities (questionnaires, word search puzzles, and mazes). At timed intervals (every 1 to 6 minutes), participants were asked to turn over their filler activity papers and to pick up a card. The card contained a description of an action or verbal response to be carried out or given later in the task upon encountering a particular cue. Cues were either auditory (e.g., an alarm), visual (e.g., a green sheet), or more subtle such as the beginning of a filler task. Cues were re-introduced after a delay varying between 2 and 15 minutes, similarly to other ProM tasks (e.g., Mateer et al., 2000). Participants then had to carry out the appropriate response. If they remembered that they had to carry out a response but were unsure of its content, they were asked to say so. The delay period between presentation (encoding) of a cue and its associated action and execution of the relevant response was filled with distractor activities, presentation of additional intentions to remember, and responses to previously introduced cues.

Whenever they picked up an index card, participants read silently the intention to be remembered as the examiner read it aloud. However, the intentions to be remembered
throughout the task could be encoded in one of three ways, depending on the encoding instructions provided on each card. Some types of encoding required a participant response. Table 7 explains each type of encoding condition.

Table 7. Instructions associated with each encoding condition.

<table>
<thead>
<tr>
<th>Encoding condition</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive condition</td>
<td>Listen to, and silently read, instructions for the intended task.</td>
</tr>
<tr>
<td>Active control condition</td>
<td>Same as in the passive condition. Also say what response has to be remembered (e.g., “ask for a new pencil”) and visualize themselves performing it.</td>
</tr>
<tr>
<td>Active test condition: Implementation intentions</td>
<td>Same as in the passive condition. Also say aloud that they intend to do action X when situation Y occurs (e.g., “I will ask for a new pencil when you drop the book on the floor” and visualize themselves performing the task in the specified context.</td>
</tr>
</tbody>
</table>

Five tasks were encoded under each type of instruction. The order of presentation of the different encoding instructions was counterbalanced in blocks within each group to prevent any differences in performance across encoding conditions from being confounded by the order of presentation of encoding instructions. The order of presentation of encoding conditions was randomly assigned to participants. To help participants remember how they had to encode a particular intention, instructions pertaining to the relevant type of encoding appeared below the description of the intended task, as shown in Figure 3. Approximately 35 seconds was allotted for encoding before the examiner turned over the card and participants resumed their filler activities.
Before participants proceeded with the PROAS test trials, sample cards were introduced and explained during task instructions. To ensure that participants understood the task requirements, three additional sample trials were then administered. The sample items were repeated until the participant correctly responded to the cues. Clarifications were provided as needed.

**Figure 3.** Card examples for the PROAS.

**Passive condition**

*When you work on a word search puzzle related to flowers, please name your favourite flower.*

**Active control condition**

*When a tape recorder is placed on the table, please take out the tape.*

Instructions: (read silently, then carry out)

1. Tell me only WHAT you have to do (but not WHEN) by saying aloud: "I will ____."
2. Picture yourself doing the task!

**Active test condition: implementation intention**

*When a sheet has rows of numbers on it, please fold the sheet in half.*

Instructions: (read silently, then carry out)

1. Tell me WHAT you have to do and WHEN by saying aloud: "I will ___ when ____."
2. Picture the situation happening and yourself doing the task!

Several materials were used for administration of the PROAS. A stamp, an inkpad, 3 different coloured pens, a pencil, a highlighter, a paper clip, and a task summary
sheet were placed on the table near the participant. The highlighter and paper clip served as distractors. A stack of papers and a tape recorder (containing an audio tape) were kept out of sight until they were required because provision of these items to the participant served as cues. Additional test materials included two stopwatches (one was running continuously, the other was used to count down the time allowed for encoding as described later), a stack of 18 (12.7 cm x 7.6 cm) index cards (3 sample cards and 15 test cards for each version of the task) on which the cues and instructions were printed, the PROAS record form, and 3 packages of filler activities. The first package consisted of 7 pages (3 word search puzzles, 3 mazes, and the CAGE questionnaire). The second package had 3 pages (the BAI, a word search puzzle, and a maze). The third package contained 6 pages (2 word search puzzles, a maze, the PROAS rating scale, a demographic questionnaire, and a number cancellation task).

The PROAS score consisted of the number of intentions correctly recalled out of 15. To be scored as correct, the appropriate response had to be made prior to presentation of the next cue to be encoded or recalled. The total score on the PROAS was converted into a percentage correct score to facilitate comparison with performance on the NYW game. The classification and analysis of error types were identical to the method used for the NYW game. However, responses were noted to be late if they were given after another cue was introduced or after another intention was recalled.

The inter-rater reliability of the PROAS was established by obtaining a reliability correlation coefficient through re-scoring of all items for which participants did not provide verbatim reproductions of the correct answers by an independent rater who was
unfamiliar with the group membership of participants. A Cohen’s Kappa statistic indicated high (94%) inter-rater agreement. Internal consistency, based on Cronbach’s alpha, was 76%. The validity of the PROAS will be addressed in the Results section.

**Cued Recall Measure for the PROAS**

At the end of the PROAS, participants were given a cued recall measure to assess memory for the content of the intention associated with each cue (8 items) or of the cue associated with each intention (7 items). The percentage of the 15 items correctly remembered was calculated.

**Rating Scales**

Four 4-point Likert-type rating scales served to rule out potential alternative explanations for any observed group differences on ProM tasks (see Appendix G). One scale was used to determine how well the NYW game intentions approximated everyday ProM demands. Subjects were asked to rate how closely the tasks to be remembered resembled situations they may encounter in their everyday life. Another scale assessed the extent to which participants used rehearsal, imagery, or another strategy to help them remember their intentions throughout the PROAS. This was done for two reasons (1) the inability to control for the possibility that an individual used mnemonic strategies to perform the task during the passive condition and (2) the inability to control for the possibility that some participants did not use active encoding strategies when instructed to do so. Finally, because lack of motivation can interfere with effort and successful task performance, two rating scales required participants to rate their motivation to perform well on each ProM task separately.
Procedure

Pilot Testing for the Prospective Memory Tasks

The tasks were piloted on four psychology students to identify any issues that would indicate the need for task modifications (e.g., ambiguous or complex instructions, ceiling or floor effects). After the first two administrations, the instructions of the NYW game were modified for enhanced clarity. Some items were also revised to make them either more applicable to everyday life, easier to understand, or to minimize interference with other items. On the PROAS, the order and timing of items were modified and more engaging filler tasks were selected based on the pilot subjects' feedback. No issues were identified during the last two administrations of the tasks to healthy pilot subjects. Based on the performance of the first four subjects with TBI, the tasks were deemed to be adequate in terms of clarity of instructions and level of difficulty.

Test Administration

Participants were tested individually by the examiner in a quiet room of a psychology laboratory or of the Psychology Clinic at the University of Victoria. Testing was completed in a single session lasting between 2.5 and 3 hours, including breaks, except for two TBI subjects who preferred to complete testing over two sessions. At the outset of the session, participants were given an overview of the study and its purpose, and written informed consent was obtained. The tests were then administered in the order outlined in Table 8. Of note, the ProM tasks were given in a counterbalanced order across subjects within each group to control for test order effects. Participants were randomly assigned to each presentation order.
Table 8. Test administration order.

<table>
<thead>
<tr>
<th>Test</th>
<th>Administration time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAART</td>
<td>5</td>
</tr>
<tr>
<td>NYW game</td>
<td></td>
</tr>
<tr>
<td>Game</td>
<td>50</td>
</tr>
<tr>
<td>Cued recall</td>
<td>3-5</td>
</tr>
<tr>
<td>Rating scales</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Break</strong></td>
</tr>
<tr>
<td>PROAS</td>
<td></td>
</tr>
<tr>
<td>PROAS task</td>
<td>50</td>
</tr>
<tr>
<td>(includes the BAI, CAGE, Demographics Questionnaire and PROAS-related rating scales as filler tasks)</td>
<td>3-5</td>
</tr>
<tr>
<td>Cued recall</td>
<td></td>
</tr>
<tr>
<td>RAVLT</td>
<td>10</td>
</tr>
<tr>
<td>BDI-II</td>
<td>5-10</td>
</tr>
<tr>
<td>Digit Span Backward</td>
<td>5</td>
</tr>
<tr>
<td>PRMQ</td>
<td>5</td>
</tr>
<tr>
<td>RAVLT-delayed</td>
<td>2</td>
</tr>
<tr>
<td>PCSC (TBI participants only)</td>
<td>5</td>
</tr>
</tbody>
</table>

*Note.* BDI-II = Beck Depression Inventory-II; NAART = North American Adult Reading Test; NYW = Navigating Your Week; PCSC = Postconcussion Syndrome Checklist; PRMQ = Prospective and Retrospective Memory Questionnaire; PROAS = Prospective Remembering of Actions and Sentences; RAVLT = Rey Auditory Verbal Learning Test.

**Power Analysis**

Calculation of a suitable sample size was based on information (means and standard deviations) derived from previous studies on ProM in TBI samples. Studies that have compared ProM between healthy adults and people with severe TBI (e.g., Groot et al., 2002; Mateer et al., 2000) found medium to large effect sizes according to Cohen’s conventions. Analysis of error type on a ProM task performed by a group with severe TBI
and a control group revealed a medium effect size for specific types of errors (Mateer et al., 2000). Finally, although no studies have investigated the effects of cue distinctiveness and implementation intentions in samples with TBI, medium effect sizes were found with other sample types (e.g., Brandimonte & Passolunghi, 1994; Chasteen et al., 2001).

Based on these studies, it was determined that a sample size of 21 participants per group would be adequate to ensure a minimum power of .80 with an alpha level of .05 to test the different hypotheses. Although many more individuals participated in the study compared to the proposed sample size, the final sample had 20 participants per group because of data exclusion for the reasons previously mentioned.

**Statistical Analyses**

An alpha level of .05 was used for statistical tests. For tests of the hypotheses, mixed model analyses of variance (ANOVARs) were used instead of multivariate analyses of variance (MANOVAs) for enhanced power. However, if the sphericity assumption was violated based on the value of the Greenhouse-Geisser Epsilon (\( \epsilon < .75 \)), multivariate analyses of variance were carried out. A Greenhouse-Geisser correction can also be used to address sphericity problems but the significance of results obtained through this method did not differ from the MANOVA results. Therefore, only the results derived from MANOVAs are reported. Finally, whenever repeated measures or MANOVA analyses were carried out on within-subjects variables that were not measured on the same scale (i.e., the two ProM tasks for one analysis and the two cued recall tests for another analysis), the dependent variable was the percentage of correct responses.
Results

Data Screening

Data screening procedures did not identify any missing data and there were no univariate outliers as defined by a standard deviation of $z \pm 3.00$ from the group mean for each test, similarly to the criteria defined by Tabachnick and Fidell (1996) ($z = \pm 3.29$). Using a conservative alpha level of .01, only the distribution of the BAI scores of the control group deviated significantly from normality based on the Shapiro-Wilks test. The homogeneity of variance assumption was satisfied for all measures based on the Levene statistic. Except for the Mann-Whitney analysis of group differences on the BAI (previously reported), parametric tests were carried out.

Preliminary Analyses

Prior to examining the hypotheses, a series of analyses were conducted, as detailed below. The first set of analyses sought to determine whether it was appropriate to collapse the individuals with TBI across levels of severity to compare their performance to that of normal controls. If performance on tasks pertaining to the main focus of this study (ProM) was found to be different based on TBI severity, then it would be necessary to compare each TBI subgroup to the control group when testing hypotheses pertaining to ProM. The second and third set of analyses were conducted to find out whether there were group differences in psychological factors or methodological issues that needed to be accounted for when comparing group performance on the tasks administered.

Impact of TBI Severity on Prospective Memory Performance and Self-Report

Separate regression analyses were run to predict either the NYW game total score,
the PROAS total score, the ProM subscale of the PRMQ, or the retrospective memory subscale of the PRMQ from TBI severity. The analyses indicated that severity of TBI did not account for a significant proportion of variance in either the ProM \( F(1,18) = .47, \text{ ns, adjusted } R^2 = -.03 \) or the retrospective memory \( F(1,18) = .13, \text{ ns, adjusted } R^2 = -.05 \) subscale of the PRMQ. Similarly, TBI severity did not predict performance on either the NYW game \( F(1,18) = 3.94, \text{ ns, adjusted } R^2 = .13 \) or the PROAS \( F(1,18) = .858, \text{ ns, adjusted } R^2 = -.008 \), although the relationship between TBI severity and performance on the NYW game approached significance. Examination of the means for each subgroup on the task revealed slightly better percentage correct scores by the subgroup with severe TBI \( (M = 56.11, SD = 22.89) \) than by the subgroup with mild TBI \( (M = 38.33, SD = 16.66) \). Nevertheless, given the lack of any statistically significant relationship between TBI severity and cognitive performance across tasks, the performance of the entire TBI sample was compared to the performance of the control group for subsequent analyses. Of note, TBI severity also did not significantly predict BDI-II scores \( F(1,18) = .34, \text{ ns, adjusted } R^2 = .04 \).

**Prediction of Performance on the PRMQ and on Cognitive Tests from the BAI and BDI-II Scores**

As stated earlier, the groups endorsed different levels of symptomatology on the BDI-II and on the BAI. Some studies suggest that the presence of depression measured by self-report or a structured diagnostic interview can be related to both self-reported and objective neuropsychological performance after TBI (e.g., Chamelian et al., 2006; Rapoport et al., 2005). To determine whether this was the case in the current sample and
to assess the possibility that similar associations involving self-reported anxiety may exist, separate hierarchical regression analyses were carried out to predict scores on each of the cognitive tests and on the PRMQ subscales from the BAI and BDI-II scores. For each regression, either the BDI-II or the BAI was first entered as a predictor, followed by group membership to determine whether the groups differed significantly on any measure after accounting for the BDI-II or the BAI scores. As shown in Table 9, performance on the BDI-II was significantly related to performance on the PRMQ subscales and on most attention and memory tests, with the exception of the RAVLT immediate recall score. Consideration was given to the fact that the BDI-II contains 2 cognitive items (i.e., concentration and decision-making difficulties) and that removal of the variance associated with self-reported cognitive difficulty would not be appropriate given that statistical analyses focus on cognitive functioning. As such, performance on each cognitive test and on the PRMQ was regressed on a new BDI-II score that excluded the two cognitive items (therefore, it was scored out of 57). Because the new BDI-II score was also related to all tests with the exception of the RAVLT immediate recall score, the original BDI-II score was used in subsequent analyses.
Table 9. Correlations between the BDI-II and other measures.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Correlation with the BDI-II (Pearson’s r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Span Backward</td>
<td>-.40*</td>
</tr>
<tr>
<td>RAVLT immediate recall</td>
<td>-.23</td>
</tr>
<tr>
<td>RAVLT delayed recall</td>
<td>-.46**</td>
</tr>
<tr>
<td>NYW game</td>
<td>-.50**</td>
</tr>
<tr>
<td>PROAS</td>
<td>-.35*</td>
</tr>
<tr>
<td>NYW game cued recall</td>
<td>-.47**</td>
</tr>
<tr>
<td>PROAS cued recall</td>
<td>-.41**</td>
</tr>
<tr>
<td>PRMQ prospective memory subscale</td>
<td>.63***</td>
</tr>
<tr>
<td>PRMQ retrospective memory subscale</td>
<td>.61***</td>
</tr>
</tbody>
</table>

*Note. BDI-II = Beck Depression Inventory-II; NYW = Navigating Your Week; PRMQ = Prospective and Retrospective Memory Questionnaire; PROAS = Prospective Remembering of Actions and Sentences; RAVLT = Rey Auditory Verbal Learning Test. *p < .05. **p < .01. ***p < .001.

By contrast, the BAI only predicted performance on the NYW game \( F(1,38) = 4.88, p = .03, \text{adjusted } R^2 = .09 \) and its associated cued recall task \( F(1,38) = 6.17, p = .02, \text{adjusted } R^2 = .12 \). Therefore, two other hierarchical regression analyses were performed. In the first one, performance on the NYW game was regressed onto the BDI-II, followed by the BAI, and finally group membership. The analysis revealed that the BAI no longer accounted for a significant proportion of the variance beyond what was already accounted for by the BDI-II \( F(1,37) = .04, \text{ns, } R^2 \text{ change } = .001 \). A similar regression analysis was carried out for the NYW game cued recall measure. It showed that the BAI did not significantly contribute to cued recall performance after the BDI-II was entered in the regression \( F(1,37) = .16, \text{ns, } R^2 \text{ change } = .003 \). Thus, only the total BDI-II score was used as a covariate in subsequent analyses involving group comparisons.
on the PRMQ and cognitive tests (except for the RAVLT immediate recall score), in an attempt to improve the statistical power of the analyses.

**Order Effects Related to the Prospective Memory Tasks**

A 2 (group) by 6 (presentation order of the encoding conditions) between-groups ANOVA revealed that the order in which encoding instructions were introduced did not significantly impact performance on the PROAS \([F(5,28) = .513, ns, d' = .22]\). For the NYW game, performance was similar across the two versions of the task \([F(1,36) = 3.33, ns, d' = .57]\).

To investigate whether the presentation order of the two ProM tasks impacted performance on each test, a MANOVA was performed on the percentage of correct responses on the NYW game and on the PROAS. The multivariate effect of group by test order was significant \([F(2, 35) = 3.39, p = .045, d' = .57]\). Follow-up univariate analyses revealed that the TBI group performed significantly worse on the PROAS when it was presented first, whereas the performance of the control group on the PROAS did not fluctuate significantly with the order of presentation of the ProM tasks \([F(1,36) = 6.56, p = .02, d' = .79]\). Two-tailed t-tests revealed that the TBI group \((M = 52.67, SD = 21.65)\) differed significantly from the control group \((M = 85.33, SD = 13.98)\) on the PROAS when it was the first ProM task administered \([t(18) = -4.01, p = .001, d' = -1.72]\), but there were no group differences when the PROAS was given after the NYW game (TBI: \(M = 71.33, SD = 10.91\); NC: \(M = 78.67, SD = 13.98\) \([t(18) = -1.31, ns, d' = -.56]\). The results are depicted in Figure 4. There was no administration order effect for the NYW game \([F(1,36) = 3.33, ns, d' = .57]\).
Prospective Memory Tasks

It was hypothesized that the group with TBI would score significantly below the control group on both ProM tasks. Due to the differential order effect for the PROAS in the TBI group, each task was analyzed separately using a one-way ANCOVA with BDI-II scores as the covariate. As shown in Figure 5, the mean number of correctly recalled intentions was significantly lower for the TBI group ($M = 8.50$, $SD = 3.87$) than for the control group ($M = 14.4$, $SD = 2.72$) on the NYW game [$F(1,37) = 16.03$, $p = .000$, $d' = 1.24$]. When the groups were compared on the PROAS regardless of the order of test administration, the analysis showed that the groups differed significantly [$F(1,17) = 7.82$, $p = .011$, $d' = 1.43$].
$p = .012, d' = 1.20]$. The TBI group recalled fewer intentions correctly ($M = 7.90, SD = 3.25$) compared to the control group ($M = 12.80, SD = 2.10$).

**Figure 5.** Mean total score on the NYW game.

![Bar chart showing mean total score for TBI and NC groups.](chart.png)

**Exploratory Analyses Involving Rating Scales**

Several rating scales were administered to participants to rule out alternative explanations for potential group differences on the ProM tasks. Because the groups differed on both ProM measures (when order effects were not considered), exploratory analyses were conducted on three rating scales to determine whether group differences could be related to differential performance motivation or differential use of mnemonic strategies by the two groups.

Regarding their motivation to perform the tasks, both groups reported having felt "much" motivated to do well on the NYW game ($t (38) = -.28, ns, d' = .09$) and on the PROAS ($t (38) = .28, ns, d' = .09$). Of note, all participants reported being at least “a
little” motivated to perform well.

In terms of the use of mnemonic strategies, both groups stated that they “often used” a strategy to help them remember to carry out activities during the PROAS ($t (38) = -0.90, ns, d' = .28$) on a scale ranging from “not at all” to “very much.” Although the use of mnemonic strategies during the NYW game was not formally assessed, the first few participants spontaneously volunteered information about their use of mnemonic strategies and subsequent participants were therefore questioned about strategy use. More than half of the participants in each group reported having repeated the intention to themselves. About 30-40% of the participants in each group claimed that they related the intention to their personal life either by visualizing themselves doing the activity in their own life or by picking a familiar choice during cue presentation. One control subject kept track of the remaining number of intentions to carry out. Three participants in each group denied using any strategy during the task. The lack of group differences on the rating scales pertaining to motivation and use of strategies on the ProM tasks is shown in Table 10.

<table>
<thead>
<tr>
<th>Rating Scale</th>
<th>TBI</th>
<th>NC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Use of mnemonics</td>
<td>3.05</td>
<td>0.89</td>
</tr>
<tr>
<td>Motivation (NYW game)</td>
<td>3.70</td>
<td>0.57</td>
</tr>
<tr>
<td>Motivation (PROAS)</td>
<td>3.75</td>
<td>0.55</td>
</tr>
</tbody>
</table>

*Note.* NYW = Navigating Your Week; PROAS = Prospective Remembering of Actions and Sentences.
Error Types on Prospective Memory Tasks

It was hypothesized that the TBI group would make primarily ProM failure errors and that the frequency of other error types would not differ significantly within the group for each ProM task. To test this hypothesis, two one-way multivariate analyses of covariance (MANCOVAs) were carried out, with the BDI-II scores partialed out. For the NYW game, the 6 dependent variables were the mean number of each of the 6 types of errors. The multivariate effect of error x group \([F(5,33) = 3.34, p = .02, d' = .57]\) was significant. Follow-up univariate analyses revealed that the TBI group made significantly more ProM failures \([F(1,37) = 9.60, p = .04, d' = .96]\) and loss of content errors \([F(1,37) = 10.39, p = .003, d' = 1.0]\) than the control group. The groups were not substantially different in terms of the frequency of other error types (see Figure 6). Before controlling for BDI-II scores, univariate analyses revealed that the TBI group also made significantly more novel response errors \([F(1,38) = 4.52, p = .04, d' = .66]\) and task substitution errors \([F(1,38) = 5.63, p = .02, d' = .74]\) than the control group.
Figure 6. Mean number of errors per error type on the NYW game.

For the PROAS, the MANCOVA yielded a significant multivariate effect of error 
\[ F(5,33) = 8.87, p = .000, d' = .92 \], but not of error by group \[ F(5,33) = 1.40, \text{ns}, d' = .37 \].
ProM failures were the main type of error across groups. Before controlling for BDI-II scores, the TBI group made significantly more ProM failures \[ F(1,38) = 6.85, p = .01, d' = .81 \], loss of content errors \[ F(1,38) = 4.75, p = .04, d' = .68 \], and repetition errors \[ F(1,38) = 6.28, p = .02, d' = .78 \] than the control group. Descriptive and inferential statistics for each type of error made on ProM tasks are presented in Table 11.
Table 11. Descriptive and inferential statistics for error types on prospective memory tasks after controlling for BDI-II scores.

<table>
<thead>
<tr>
<th>Error type</th>
<th>TBI</th>
<th></th>
<th>NC</th>
<th></th>
<th>Group statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
<td>$F$</td>
</tr>
<tr>
<td>ProM failure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYW</td>
<td>.430</td>
<td>.236</td>
<td>.165</td>
<td>.184</td>
<td>.960**</td>
</tr>
<tr>
<td>PROAS</td>
<td>.270</td>
<td>.251</td>
<td>.110</td>
<td>.107</td>
<td>3.54</td>
</tr>
<tr>
<td>Task substitution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYW</td>
<td>.50</td>
<td>.69</td>
<td>.10</td>
<td>.31</td>
<td>2.51</td>
</tr>
<tr>
<td>PROAS</td>
<td>.60</td>
<td>.68</td>
<td>.25</td>
<td>.44</td>
<td>4.78*</td>
</tr>
<tr>
<td>Novel response</td>
<td></td>
<td></td>
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<tr>
<td>NYW</td>
<td>.90</td>
<td>1.25</td>
<td>.25</td>
<td>.55</td>
<td>.68</td>
</tr>
<tr>
<td>PROAS</td>
<td>.15</td>
<td>.37</td>
<td>.10</td>
<td>.45</td>
<td>.07</td>
</tr>
<tr>
<td>Repetition</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>NYW</td>
<td>.10</td>
<td>.31</td>
<td>.05</td>
<td>.22</td>
<td>.06</td>
</tr>
<tr>
<td>PROAS</td>
<td>.20</td>
<td>.41</td>
<td>.00</td>
<td>.00</td>
<td>2.80</td>
</tr>
<tr>
<td>Loss of content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYW</td>
<td>3.35</td>
<td>1.76</td>
<td>1.35</td>
<td>1.14</td>
<td>10.39**</td>
</tr>
<tr>
<td>PROAS</td>
<td>1.60</td>
<td>1.35</td>
<td>.70</td>
<td>.87</td>
<td>3.01</td>
</tr>
<tr>
<td>Approximation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYW</td>
<td>.30</td>
<td>.47</td>
<td>.20</td>
<td>.41</td>
<td>.78</td>
</tr>
<tr>
<td>PROAS</td>
<td>.40</td>
<td>.60</td>
<td>.55</td>
<td>.61</td>
<td>.39</td>
</tr>
</tbody>
</table>

Note. NYW = Navigating Your Week; ProM = prospective memory; PROAS = Prospective Remembering of Actions and Sentences.

* $p < .05$; ** $p < .01$.

Effect of Cue Saliency

It was hypothesized that the performance of the TBI group on the NYW game would be below that of controls regardless of cue saliency, but that the TBI group would perform significantly better in the presence of perceptually distinctive cues as compared to
their performance under non-salient cue conditions. To test this hypothesis, a 2 (group) x 2 (cue saliency) ANCOVA, with repeated measures on the cue saliency factor and the BDI-II scores covaried out, was performed on the percentage of correct responses provided within each saliency condition. The analysis revealed a main effect of group \[F(1,37) = 16.03, p = .000, d' = 1.24\], such that the TBI group performed significantly below the control group regardless of the saliency condition. However, there was no main effect of cue saliency \[F(1,37) = .23, ns, d' = .15\] or interaction effect of group by cue saliency \[F(1,37) = .12, ns, d' = .11\]. Similar results were obtained prior to accounting for BDI-II scores.

**Exploratory Analyses Involving Error Type**

To investigate the possibility that the lack of cue saliency effect on overall ProM performance is due to masking of a specific effect of cue saliency only on the prospective component of ProM, two exploratory analyses were carried out.

The first analysis explored whether cue saliency had an impact on the frequency of ProM failures (thought to reflect the prospective component of ProM) within each group. Because more attention may be directed toward a cue when it is salient (e.g., Brandimonte & Passolunghi, 1994), individuals within each group who manifested ProM failures may have increased their responding (made fewer ProM failures) when cues were salient rather than non-salient. To assess this possibility, a 2 (group) x 2 (cue saliency) ANCOVA, with repeated measures on the cue saliency factor and the BDI-II covaried out, was performed on the percentage of ProM failure errors made (out of all ProM failure errors on the NYW game) under each saliency condition when including only those participants who made at
least one such error (everyone with TBI and 13 out of 20 controls). A main effect of saliency [$F(1,30) = 5.07, p = .03, d' = .78$] was significant. The main effect of group [$F(1,30) = 1.61, ns, d' = .44$] and the group x saliency interaction were not significant [$F(1,30) = .19, ns, d' = .15$]. Therefore, when considering only people who failed to respond to some items on the NYW game, participants within each group responded more frequently (i.e., had fewer ProM failures) when the cues were salient rather than non-salient. The results of the analysis are depicted in Figure 7.

**Figure 7.** Mean percentage of prospective memory failures under each cue saliency condition.
An additional exploratory analysis was conducted to investigate whether the impact of cue saliency was unique to the prospective component of ProM (as measured by ProM failures) and therefore not also observed for the retrospective component (loss of content errors). To this end, the effect of cue saliency on the percentage of loss of content errors by individuals who made at least one such error was analyzed with a 2 (group) x 2 (cue saliency) ANCOVA, with repeated measures on the cue saliency factor and the BDI-II performance as a covariate. There was no significant main effect of cue saliency \[F(1,30) = .07, ns, d' = .09\].

**Effect of Encoding Condition**

It was hypothesized that the TBI group would score lower than controls on the PROAS regardless of encoding condition, but that the TBI group would perform differently across encoding conditions. Specifically, it was predicted that they would perform significantly better under the implementation intention condition than in either the passive or active control conditions. This hypothesis was tested using a 2 (group) x 3 (encoding instruction) ANCOVA, with repeated measures on the encoding instruction factor and performance on the BDI-II as a covariate. The analysis showed that the percentage of correct responses was similar across the three encoding conditions \[F(2,74) = 2.13, ns, d' = .45\]. The main effect of group was significant \[F(1,37) = 7.13, p = .01, d' = .83\], but the interaction of group by encoding condition was not \[F(2,74) = .40, ns, d' = .20\]. The results held true when BDI-II scores were not accounted for.
Relationships Between Scores on Prospective Memory Tasks and on Other Cognitive Tests

Both primary and secondary analyses were carried out, as explained below. The results are shown in Table 12.

*Rey Auditory Verbal Learning Test and Cued Recall Measures*

To test the hypothesis that performance on both ProM tasks would be positively related to performance on retrospective memory measures in the TBI group, correlations were run between scores on the ProM tasks and on the RAVLT and measures of cued recall. The performance of TBI participants on both ProM tasks showed a medium to large positive relationship to cued recall tests. The PROAS also showed a medium positive correlation with RAVLT delayed recall scores in the TBI group.

*Digit Span Backward*

Given the purported link between working memory and ProM in people with TBI (Kliegel et al., 2000; Schmitter-Edgecombe & Wright, 2004) and the relatively few studies on this topic, a secondary analysis was conducted to assess this potential relationship. The analysis revealed a medium correlation between scores on ProM tasks and on Digit Span Backward for TBI participants.
Table 12. Partial correlations between prospective memory tasks and other cognitive measures after controlling for BDI-II scores.

<table>
<thead>
<tr>
<th>Measure</th>
<th>NYW game partial Pearson’s r</th>
<th>PROAS partial Pearson’s r</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TBI</td>
<td>NC</td>
</tr>
<tr>
<td>Digit Span Backward</td>
<td>.46*</td>
<td>-.30</td>
</tr>
<tr>
<td>RAVLT immediate recall</td>
<td>.22</td>
<td>.18</td>
</tr>
<tr>
<td>RAVLT delayed recall</td>
<td>.39</td>
<td>-.30</td>
</tr>
<tr>
<td>NYW cued recall</td>
<td>.90**</td>
<td>.94**</td>
</tr>
<tr>
<td>PROAS cued recall</td>
<td>.46*</td>
<td>.42</td>
</tr>
</tbody>
</table>

Note. NYW = Navigating Your Week; PROAS = Prospective Remembering of Actions and Sentences; RAVLT = Rey Auditory Verbal Learning Test.
* p < .05. ** p < .01, *** p < .001.

Relationship Between Prospective Memory Performance and Memory Self-Ratings

Self-ratings of retrospective and prospective memory (retrospective memory and ProM subscales of the PRMQ) were expected to be positively associated with performance on both ProM tasks in the TBI group. However, calculation of partial Pearson correlations (BDI-II scores partialed out) revealed that the PRMQ subscales were not significantly related to performance on either ProM task in the TBI group (see Table 13). Similar results were obtained prior to controlling for BDI-II scores.
Table 13. Partial correlations between the PRMQ subscales and prospective memory tasks after controlling for BDI-II scores.

<table>
<thead>
<tr>
<th>PRMQ</th>
<th>NYW game</th>
<th>PROAS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>partial Pearson’s r</td>
<td>partial Pearson’s r</td>
</tr>
<tr>
<td></td>
<td>TBI</td>
<td>NC</td>
</tr>
<tr>
<td>ProM subscale</td>
<td>-.23</td>
<td>-.14</td>
</tr>
<tr>
<td>Retrospective memory subscale</td>
<td>.01</td>
<td>-.26</td>
</tr>
</tbody>
</table>

Note. NYW = Navigating Your Week; PROAS = Prospective Remembering of Actions and Sentences; PRMQ = Prospective and Retrospective Memory Questionnaire.
* p < .05, ** p < .01.

Secondary Analyses on Objective and Self-Report Measures

Prospective and Retrospective Memory Questionnaire

The TBI and control groups were compared in terms of their self-ratings for both the retrospective and prospective aspects of memory functioning for two reasons: (1) the PRMQ had not previously been administered to a sample with TBI despite relatively extensive literature on self-awareness of cognitive deficits and (2) the PRMQ allows for the comparison of self-awareness for prospective and retrospective memory problems post-TBI. An ANCOVA [2 (group) x 2 (PRMQ subscale)] was carried out, with repeated measures on the PRMQ subscale factor. As shown in Figure 8, there was a significant main effect of subscale [$F(1,37) = 4.89, p = .03, d' = .69$], with greater endorsement of ProM items. There was also a significant main effect of group [$F(1,37) = 16.88, p = .000, d' = 1.27$], such that the TBI group reported more problems with memory (ProM subscale: $M = 27.25, SD = 6.13$; retrospective memory subscale: $M = 24.10, SD = 4.89$) than the control group (ProM subscale: $M = 18.80, SD = 4.64, d' = .91$; retrospective memory subscale: $M = 14.85, SD = 3.30, d' = 1.54$). The interaction of group by subscale was not
significant \(F(1,37) = 2.34, \text{ns, } d' = .47\). Similar results were obtained before controlling for BDI-II scores.

**Figure 8.** Mean total score per subscale on the PRMQ.

![Figure 8](image)

*Retrospective Memory and Working Memory Measures*

A series of secondary analyses were carried out on the objective cognitive measures administered to comment on other aspects of cognitive status (i.e., retrospective memory, working memory) in the TBI participants as compared to controls.

To compare group performance across the cued recall measures associated with the NYW game and the PROAS, the raw scores on each task were converted to percentage scores (total number of correct responses divided by total number of items) to put them on the same scale for a repeated measures analysis. An ANCOVA [(2) group x (2) cued
recall task] was carried out on the percent scores, with repeated measures on the task factor and the BDI-II as the covariate. The analysis revealed a significant main effect for group only \([F(1,37) = 13.48, p = .001, d' = 1.14]\), indicating that control subjects outperformed participants with TBI on the cued recall measures. Similar results were obtained when BDI-II scores were not accounted for. Table 14 lists the raw means and standard deviations for the NYW game and the PROAS cued recall measures.

The groups did not differ significantly on the immediate recall score (i.e., the mean of the scores on Trial 1 and List B) of the RAVLT \([F(1,38) = 2.61, ns, d' = .50]\) using a one-way ANOVA. To compare group performance on the delayed recall trial, BDI-II scores were used as a covariate in an ANCOVA. Again, no significant group differences were found \([F(1,37) = .522, ns, d' = .22]\). Prior to statistically controlling for BDI-II scores, the control group outperformed the TBI group on the delayed recall trial \([F(1,38) = 4.80, p = .04, d' = .68]\). Descriptive statistics for the RAVLT measures are provided in Table 14.

Significant group differences were not observed on Digit Span Backward, after controlling for the BDI-II scores using a one-way ANCOVA \([F(1,37) = 2.17, ns, d' = .46]\). Before covarying out the BDI-II scores, the groups differed significantly, with the TBI group performing below the control group \([F(1,38) = 7.03, p = .01, d' = .82]\). The means and standard deviations for attention and retrospective memory tests are presented in Table 14.
Table 14. Descriptive statistics for attention and retrospective memory tests.

<table>
<thead>
<tr>
<th>Cognitive Test</th>
<th>TBI (M, SD)</th>
<th>NC (M, SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Span Backward</td>
<td>7.25 (1.8)</td>
<td>8.85 (2.01)</td>
</tr>
<tr>
<td>RAVLT immediate</td>
<td>11.65 (3.68)</td>
<td>13.15 (1.93)</td>
</tr>
<tr>
<td>RAVLT delayed recall</td>
<td>10.2 (3.58)</td>
<td>12.25 (2.17)</td>
</tr>
<tr>
<td>NYW game cued recall</td>
<td>9.25 (3.75)</td>
<td>14.65 (2.83)</td>
</tr>
<tr>
<td>PROAS cued recall</td>
<td>9.75 (2.83)</td>
<td>12.65 (1.87)</td>
</tr>
</tbody>
</table>

*Note.* NYW = Navigating Your Week; PROAS = Prospective Remembering of Actions and Sentences; RAVLT = Rey Auditory Verbal Learning Test.

**Prospective Memory Tasks**

Exploratory analyses were conducted to attempt to establish the validity of the experimental ProM measures. To comment on the construct validity of the NYW game and of the PROAS in the TBI group, Pearson Product Moment correlations were calculated between scores on the two ProM tasks after statistically controlling for BDI-II scores. Analyses were performed for each group separately. There was a significant positive correlation between performance on the NYW game and on the PROAS after controlling for BDI-II scores ($r = .49, p < .05$ for the TBI group; $r = .51, p < .05$ for the control group). Another exploratory analysis was conducted to determine the face validity of the NYW game. Both the TBI ($M = 3.05, SD = 0.76$) and NC ($M = 3.08, SD = 0.83$) groups reported the activities described in the NYW game to be “moderately similar” to things they may have to remember in their daily life ($t (38) = .00, ns$) on a scale ranging from “different” to “extremely similar.”
Discussion

The cognitive processes underlying ProM deficits post-TBI remain unclear. Furthermore, ProM investigations have been limited to individuals with severe TBI and have not aimed to identify factors that may enhance prospective remembering in this population. Therefore, this dissertation analyzed the characteristics of event-based ProM in individuals with a range of TBI severity that were age-, gender-, and education-matched to healthy controls. Additionally, the current study sought to determine: (1) the types of errors made by individuals with TBI on ProM tasks, (2) the effects of perceptual cue distinctiveness and the formation of implementation intentions on the ability to remember to perform intended actions in TBI, (3) the relationship between ProM and retrospective memory performance, and (4) the relationship between objective ProM performance and self-reported ProM based on the PRMQ.

As mentioned, previous studies of ProM in TBI restricted their samples to individuals with a severe injury. Although the current study initially proposed to include only individuals with mild to moderate levels of TBI severity, the final sample was equally divided into people with mild TBI and people with severe TBI due to recruitment problems. Because the subgroups (mild versus severe TBI) performed similarly on the measures of subjective and objective ProM, the results will be discussed for the entire TBI sample.

Prior to analyzing performance on the various measures, the TBI and normal control groups were compared on the BDI-II, and the relationship between performance on the BDI-II and on other tasks was examined. Because the results indicated that: (1) the
TBI group scored significantly higher than the control group on the BDI-II and (2) BDI-II scores were related to performance on the PRMQ and on all cognitive measures (except for the RAVLT immediate recall score), the BDI-II scores were subsequently covaried out whenever they were related to the dependent variable. Although the TBI group also endorsed more symptoms on the BAI, this measure was related solely to performance on the NYW game. The BAI was not used as a covariate in the analysis of this ProM task because the relationship between the BAI and the NYW game was no longer significant after BDI-II scores were considered.

Overall, the results of this dissertation revealed that the TBI group obtained lower scores than normal controls on both event-based ProM tasks after accounting for BDI-II scores, although the groups did not differ when the PROAS was administered after the NYW game. The TBI group committed various types of errors but ProM failures and loss of content errors were particularly prominent on the NYW game. Salient cues did not help people with TBI fulfill more intentions on this task, with the overall number of errors being similar across saliency conditions. However, salient cues did increase the frequency with which people with TBI responded (accurately or not) to the cues (i.e., the salient cues reduced the frequency of ProM failures). The formation of implementation intentions did not prove beneficial on the PROAS. The scores of the TBI group on the ProM tasks were unrelated to their immediate recall scores on the RAVLT but the PROAS was related to the delayed recall trial of the RAVLT. Although the TBI group reported more problems with ProM on the PRMQ as compared to controls, higher endorsement of such difficulties was not associated with lower scores on either of the ProM tasks. These results, and those
yielded by additional exploratory analyses carried out to investigate alternative hypotheses, will be discussed.

Order Effects

A counterbalancing approach was used in an attempt to control for confounding effects due to the order in which encoding instructions were introduced to each participant on the PROAS or to the order in which the ProM tasks were administered within the session. Two versions of the NYW game contained identical items that were differentially salient across versions. Each test version was given to half of the participants within each group to control for potential differences in item difficulty between salient and non-salient items.

The results did not reveal differential performance on the NYW game based on the test version administered, suggesting that the effects of salient versus non-salient cues on ProM performance could be reliably examined. The order of administration of encoding instructions did not have a differential impact on performance on the PROAS, indicating that the effects of encoding condition on ProM performance could also be reliably assessed.

The order in which the ProM tasks were administered did not significantly influence performance on the NYW game. By contrast, the TBI and control groups were differentially sensitive to the order of administration of the PROAS relative to the NYW game. The TBI group obtained higher scores on the PROAS when it followed the NYW game but no such effect was noted for the controls. Therefore, group differences on the PROAS when it was the first ProM measure administered disappeared when its
administration followed the NYW game.

There may be several explanations for the differential test order effect on the PROAS based on group membership. Consideration was given to a possible ceiling effect for the control group on the PROAS because 6 of the controls scored either 14 or 15/15 on the PROAS when it was administered first. However, the fact that the control group's performance actually declined slightly and was only 78% when the PROAS was the second ProM task given renders this explanation unlikely.

Temporary effects related to participant characteristics such as fatigue, cognition, and anxiety, were also ruled out as potential explanations. Fatigue, although reported by most participants with TBI, would have been expected to increase over the session and, consequently, to lower scores on the second ProM test. Fluctuations in cognitive factors such as attention would have been expected to occur throughout the session and not to unduly influence performance on a single task based on its order of administration. Lastly, self-reports of anxiety on the BAI were not related to performance on the PROAS. The possibility remains, however, that participants with TBI experienced anxiety during the session that was not accurately captured by the BAI, and that their anxiety level was higher when the PROAS was presented first because of the complexity of the encoding instructions.

Order effects specific to the PROAS in the TBI group could imply that something within the NYW game helped TBI participants subsequently do better on the PROAS. Such order effects may represent practice effects related to previous exposure to a ProM test. Engaging in the NYW game may have improved TBI participants' comprehension of
ProM task requirements (e.g., having to remember a cue and its association to an intention to be carried out during cue re-introduction) or allowed them to practice the cognitive skills underlying ProM task performance (e.g., use of mnemonic strategies). The absence of a similar effect of the PROAS on the NYW game may be related to differences between the ProM tasks. The memory requirements of the NYW game may have been more explicit because the instructions focused almost exclusively on having to remember intentions compared to the relatively significant proportion of the PROAS instructions spent on explaining the three encoding conditions. Therefore, participants would have more quickly grasped test demands pertaining to ProM measures when first exposed to the NYW game rather than the PROAS.

An equally plausible explanation is that something about the PROAS led TBI participants to perform particularly poorly when it was the first ProM task given. Additional instructions related to an experimental manipulation were provided only for the PROAS, with no mention of the cue saliency manipulation during the NYW game instructions. Therefore, when the PROAS was presented first, participants would have had to process and retain novel, lengthy, and relatively detailed instructions pertaining to both ProM demands and encoding instructions. These two sets of novel and complex task instructions for the first administration of the PROAS may have overloaded TBI participants' attentional capacity and memory system. Indeed, a few people from the TBI group confused the various encoding instructions during the sample and test trials.

In sum, the reason for the differential test order effect in the two groups is not clear. Similarly, the extent to which the order of test administration may have influenced
the validity of the PROAS as a ProM measure at either administration time point cannot be ascertained. It was therefore decided that using the mean score across the two PROAS administrations for subsequent analyses was the most appropriate (though not ideal) approach. Furthermore, this approach had the advantage of providing more statistical power (due to a larger sample size) compared to analyses restricted to the PROAS when administered as the first or the second ProM task.

**Status of Prospective Memory after TBI**

As predicted, the TBI group carried out fewer intentions than the control group on both the NYW game and the PROAS (when the test administration order was not considered). The large effect sizes obtained for both ProM tasks indicate that people with TBI may have clinically significant difficulty in situations requiring the formation and delayed retrieval of more than one intention. The results are consistent with previous reports of ProM impairment in samples of individuals with severe TBI (e.g., Hannon et al., 1995; Schmitter-Edgecombe & Wright, 2004; Shum et al., 1999) but they also suggest that ProM deficits may be present in people with mild TBI, an area not yet investigated in the TBI literature. In fact, individuals with mild TBI performed slightly (although not significantly) worse than people with severe TBI on the NYW game. This was not accounted for by differences in the subgroups’ level of psychological distress or their level of self-awareness for their memory difficulties. As such, this tendency toward better performance by people with more severe TBI is difficult to explain. Further investigations with larger sample sizes are necessary to reliably compare ProM performance in groups with mild and severe TBI.
Most of the previous studies required participants to perform a single type of response whenever a cue was presented. Although the investigations shed light on the prospective component of ProM (remembering to remember), they did not reflect the complexity of ProM demands that occur in everyday life when we must remember a variety of intentions, each associated with a particular moment considered ideal for carrying out the intended action. The current study was the first investigation of event-based ProM post-TBI that employed tasks involving multiple cues and multiple intended actions, thus allowing better assessment of the retrospective and prospective components of ProM and providing a better approximation of daily ProM demands. Cognitive processes such as encoding, retrieval, interruption of an ongoing activity, cue recognition, and initiation and execution of intentions are thought to underlie ProM performance and to be mediated by the frontal and temporal regions (Glisky, 1996). Findings of ProM deficits are therefore consistent with the pathophysiology of TBI frequently involving contusions to these brain areas.

Of the multiple factors that could potentially have confounded the analysis of ProM, various participant-related characteristics are deemed unlikely to be sufficient to explain the group differences. First, the role of depressive symptomatology can be ruled out given persistent group differences after controlling for differences on the BDI-II. The groups were similar in terms of age, years of education, gender, level of pain, and substance use history, thus ruling out the potential contribution of these factors to differential group performance. Litigation status is also unlikely to have accounted for group differences because only three TBI subjects were involved in litigation. Also,
participants were informed that the results would be used solely for research purposes, thereby discouraging purposefully reduced effort on the tasks. There is a possibility that greater use of psychoactive medications by TBI participants (3:1 ratio) may have contributed to group differences on cognitive tests, particularly on episodic memory tasks (Wadsworth et al., 2005); however, new anticonvulsants and antidepressants have usually been reported to have either minimal or beneficial effects on cognition (Gorenstein et al., 2006; Meador, 2003). Fatigue, although reported by almost twice as many TBI participants as controls (85% vs. 45% on the BDI-II), is not thought to have significantly impacted performance because (1) participants were tested at their preferred time of day, (2) testing was completed over two sessions whenever requested, (3) breaks were provided during the session, and (4) group differences on the NYW game were noted regardless of when the task was administered.

Group differences in the use of mnemonic strategies could also translate into differential ProM performance. To rule out this explanation, exploratory analyses were conducted. However, both groups rated that they “often used” mnemonic strategies during the PROAS. Qualitatively, more than half of participants within each group claimed to have repeated intentions to themselves throughout the NYW game. Furthermore, a similar percentage (30-40%) of people in each group related the intention to their personal life by visualizing themselves performing the task or by picking a familiar choice, whereas three participants per group denied using any strategy.

One alternative explanation that was not considered is that the filler activities required greater deployment of effort and attentional resources in the TBI group, thereby
reducing the resources available to perform the ProM tasks. The filler activities served as either ongoing activities to be interrupted or as distractors intended to prevent the rehearsal of intentions. Informal observations suggest that the control participants completed more pages of filler activities than controls for the NYW game. On the PROAS, the control group tended to complete more mazes and to circle more words per word search puzzle compared to the TBI group. Nevertheless, the filler activities were relatively simple and chosen to place minimal demands on attentional resources, with presumed emphasis primarily on speed of visual scanning and mental processing.

According to McDaniel and Einstein’s (2000) multiprocess framework, the more strategic and attentionally-demanding processes are involved in prospective remembering, the greater the deficits in ProM. Several features of the NYW game employed in the current study suggest that it emphasized primarily strategic rather than automatic processes. Specifically, it could be argued that the NYW game required strategic processes because of its relatively high level of task absorption and complexity, and the lack of an association between several cues and actions. First, participants’ report of being “much” motivated to perform well on the ProM tasks, their informal comments denoting enjoyment of the NYW game, and the multiple ongoing activities (several cue-action associations) that they had to keep in mind suggest a high level of task absorption. Consequently, less time would presumably be spent thinking about intended actions. Second, the cues and intended actions were not always associated semantically (e.g., remembering to pick up dry-cleaning after going to the dentist). Lastly, it is possible that reintroduction of a cue in a novel context (where another action is described) increased the
need for controlled attentional processes to monitor for the cue. Some participants may have focused their attention on the new action described and therefore engaged in less cue monitoring.

By contrast, the PROAS may have relied to a larger extent than the NYW game on automatic processes because half of its cues could be described as “obvious” or salient. Indeed, they frequently involved the examiner placing objects on the table or interrupting the silence to make a statement. Half of the cues were also closely associated with their relevant intentions. For example, participants were asked to say whether the tape was rewound when the tape recorder was placed on the table and to ask for the time when they were shown a watch. The lack of group differences on the PROAS when it was administered as the second task suggests that the PROAS may not have been as sensitive to ProM deficits as the NYW game. This could be secondary to either the obvious nature of the cues, to their close link to the relevant intentions, or to both factors. The lack of group differences also suggests that ProM deficits may be attenuated (or eliminated) in people with TBI when ProM tasks emphasize relatively automatic rather than more strategic processes. This idea is consistent with the notion that automatic processes are relatively preserved post-TBI as compared to controlled attentional processes.

**Pattern of Errors on Prospective Memory Tasks after TBI**

Based on past studies, it was predicted that the TBI group would make primarily ProM failures (omissions of responses), with no significant differences in the frequency of other error types. However, the findings showed that not only did TBI participants frequently fail to respond when cues were reintroduced (ProM failures) but they also often
claimed not to remember “what to do” across both ProM tasks (loss of content errors). On the NYW game, both error types were committed significantly more frequently by TBI participants than by the control group. On the PROAS, the TBI group again made primarily ProM failures, followed by loss of content errors, but not significantly more than the control group. The lack of group differences for these error types may be related to the obvious nature of the cues and to the close semantic association between cues and intentions, which may have facilitated automatic detection of the cues and spontaneous retrieval of the relevant intentions. Before controlling for the effects of depressive symptomatology, the TBI group made more novel responses and task substitution errors than controls on the NYW game and more ProM failures, loss of content errors, and repetitions on the PROAS.

Failure to respond to a cue has been interpreted to reflect the prospective component of ProM, with an inability to “remember to remember” or to remember that something has to be done at a particular moment (when external cues are presented). However, as pointed out by Kvavilashvili (1987), forgetting that an intended action has to be carried out does not necessarily imply that the content of the intention (“what to do”, the retrospective component of ProM) has also been forgotten. It is not possible to establish with certainty whether the content of the intention was preserved for those cues that did not elicit a response because such content would be retrieved only upon noticing or recognizing a cue. However, asking participants to indicate instances where they remembered to do something but could not recall what to do did help to differentiate between errors related to the prospective and retrospective components of ProM, as
demonstrated by the high number of loss of content errors.

Several processes have been identified as potentially having a large impact on the prospective component of ProM, including the ability to monitor the environment for the cue (Bisiacchi, 1996; Burgess & Shallice, 1997; Einstein & McDaniel, 1996; Krishnan & Shapiro, 1999), the ability to recognize the cue as a signal that something has to be done (Brandimonte & Passolonghi, 1994; McDaniel et al., 1999), and the ability to properly encode a cue and the intended action (Burgess & Shallice, 1997; Krishnan & Shapiro, 1999; McDaniel et al., 1999). The ability to switch attention and either inhibit or interrupt an ongoing task (McDaniel et al., 1999) has also been implicated in ProM but it is presumed to be implicated mainly in time-based ProM tasks where people must monitor the passage of time and self-initiate the action to be carried out (Einstein & McDaniel, 1990).

With respect to the ProM tasks administered in the current study, the reason for the elevated number of ProM failures in the TBI group is not clear. One possibility is that the cues were not properly encoded as signals that something needed to be done. The TBI participants’ lower proportion of correctly recalled cues and intentions upon cued recall could be attributable to encoding problems. However, assessment of recognition performance would provide more support for this hypothesis.

The high frequency of ProM failures by TBI participants may be due to inconsistent monitoring of the environment for cues. This explanation would be compatible with Schmitter-Edgecombe and Wright’s (2004) report that individuals with TBI showed fluctuations in their responses to cues, with a tendency to “recover” from
their omissions and to respond on subsequent presentation of the same cue. They referred to this phenomenon as momentary lapses of “intention.” The authors believed such lapses to be attributable to either (1) working memory deficits related to problems with allocation of attentional resources or capacity or to (2) problems with attentional modulations over the course of the task (i.e., sustained attention). As will be discussed later, working memory likely contributed to performance on the current ProM tasks. On the other hand, it is also possible that the high frequency of ProM failures is related to a failure to recognize some cues as signals to perform intentions because of fluctuating attention. The relative contribution of deficits in working memory and sustained attention to ProM failures cannot be disentangled in the present study because participants’ ability to sustain attention was not assessed.

A few authors have commented on the resemblance of ProM tasks to vigilance paradigms (e.g., Knight et al., 2006). Indeed, both types of paradigms require that an individual monitor the environment for the appearance of a target stimulus and respond appropriately when the stimulus is noticed. Therefore, it would appear that ProM and vigilance tasks both involve the ability to notice a relevant stimulus. However, a number of task features differentiate vigilance paradigms and the ProM tasks used in the current study. In vigilance tasks, minimal load is placed on the response required (e.g., a simple key press), only one or very few of the stimuli presented require a response, the target stimuli are introduced within a string of similar stimuli in a continuous activity, and reaction time is often measured. By contrast, the current ProM tasks placed more emphasis on memory processes and on future-oriented behaviours, with analysis of the
number of correctly recalled intentions. In the NYW game and the PROAS, participants
had to form multiple cue-intention associations in memory and to retrieve and carry out
each intended action in response to a different cue. Several of the participants' comments
during the ProM tasks (e.g., that they forget to do things they had intended to do) suggest
that they viewed the tasks as measures of memory. Furthermore, while a failure to
respond to a target in a vigilance task would be interpreted as a lapse of attention, failure
to respond to a cue in a ProM test could be related to failure to notice the cue, to recognize
it as a signal that something needs to be done at that moment, or to switch attention and
interrupt an ongoing task. Encoding processes are also presumed to be involved in ProM.
In sum, there may be some overlap in the abilities required by vigilance and ProM tasks,
but additional cognitive processes (such as retrospective memory) were required by the
ProM activities administered in the current study.

Difficulties with the switching of attention or inhibition of one’s responses to an
ongoing task are unlikely to account for group differences in the frequency of ProM
failures on the NYW game. The fact that participants had to respond only when they
picked up a card is assumed to have lessened participants’ need for self-initiation of
attentional switching.

The heavy load placed on the content of intentions in the current study compared
to previous studies of ProM in TBI may account for the higher number of non-omission
errors compared to the findings reported by Mateer et al. (2000) and by Shum et al.
(1999). The latter studies involved either the same response each time a cue appeared or a
few different responses carried out to a minimal number of cues. Consequently, lower
ProM scores in their TBI samples may have reflected primarily failures to remember to respond to the cues (ProM failures). By contrast, participants in this study had to remember to carry out 18 different intentions within the NYW game and 15 different intentions within the PROAS in response to an equivalent number of different cues. Therefore, the content of intentions was more likely to have been forgotten or associated with the wrong cue.

The fact that participants with TBI frequently forgot what to do in addition to forgetting when to perform intended actions suggests that failure to carry out intentions post-TBI may reflect significant difficulties with both the retrospective and the prospective components of ProM. Loss of content errors could indicate problems with (1) the retrieval of intentions upon cue detection (McDaniel et al., 1999), (2) the formation of associations between cues and intentions at encoding (Einstein et al., 1992), or (3) both encoding and retrieval. The fewer proportion of correctly recalled pairings of cue-intention on the cued recall measure administered after each ProM task could provide evidence for either retrieval or encoding difficulties. As noted earlier, a multiple-choice format would have been useful to determine whether the link between each cue and intention had been properly encoded. Regardless of the contribution of encoding and retrieval mechanisms to impaired ProM performance in the TBI group, the findings indicate that noticing a cue was insufficient to automatically trigger retrieval of the intended action, at least within the NYW game. Results for the NYW game appear to be consistent with the Notice + Search model proposed by Einstein and McDaniel (1996). The model specifies that noticing a cue triggers an effortful and controlled search of
retrospective memory for the meaning of the cue (i.e., “What was I supposed to do when X occurs?”), but that proper encoding may impact the search for the content of the intention.

In addition to ProM failures and loss of content errors, participants also showed a tendency to perform an intended action in response to the wrong cue (task substitution) or to carry out an activity that was not a previously formed intention when a cue appeared (novel responses). The groups also made approximation errors, that is, they sometimes carried out the correct action with the wrong object or the wrong action with the correct object. Task substitutions, novel responses, and approximations may be conceptualized to reflect problems with the retrospective component of ProM, along with loss of content errors; however, they may also be associated with interference effects. On the NYW game, most novel responses pertained to multiple choice activities listed on the cards or to sample items presented during task instructions. Across ProM tasks, approximations often occurred for intended actions (e.g., “I have to buy”) that were common to several items (e.g., “milk” versus “a magazine”) or to actions inherent in several cues (e.g., “when you are given a questionnaire” versus “given a new word search puzzle”). According to Carey et al. (2006), interference effects may be due to a breakdown in the encoding process, with inaccurate associations between cues and intentions, or in the retrieval process. Regardless of the nature of the disturbance, participants would notice and recognize cues but respond with the incorrect action. Future studies could further assess the relationship between the three error types and consider combining them as interference errors to maximize statistical power and to better relate patterns of errors to cognitive constructs.
The relatively few repetition errors made by TBI participants across ProM tasks indicate a relatively preserved ability to monitor output and to retain information about whether an intention was previously carried out. This interpretation only applies to situations where distinct responses have to be carried out upon exposure to different external cues. Furthermore, output monitoring is particularly important for repetitive tasks (Einstein et al., 1998; Ellis, 1998) and may have been less emphasized in the current study.

**Effect of Cue Saliency on Prospective Memory**

It was hypothesized that TBI participants would perform better on ProM tasks when cues were salient rather than non-salient, although their scores were expected to remain below those of the control group. This hypothesis was not supported, with the TBI group obtaining similar scores across saliency conditions that consistently fell below the scores of the control group. In retrospect, these results are not surprising because of the high retrospective component involved in the ProM tasks. The studies that reported an impact of perceptual cue saliency (e.g., change in font) on ProM performance required a single type of response upon cue detection. Participants simply had to remember “when” to perform the response (e.g., Brandimonte & Passolonghi, 1994; McDaniel et al., 1999). Therefore, the positive findings in those studies may have been attributable to the effect of cue saliency on the prospective component of ProM. This idea is supported by Cohen et al. (2001), who showed that perceptual cue features impact on the prospective component, but not on the retrospective component, of ProM. In sum, because the content of the intention was easy to retrieve in previous investigations of ProM, salient cues would have
had parallel effects on both the frequency of responses to cues and the overall ProM scores. By contrast, because of the complexity and the number of intentions to be recalled in the present study, the lack of an improvement in scores on the NYW game under salient cue conditions would not necessarily imply that omission errors were committed with similar frequency across cue saliency conditions. Participants’ scores on the NYW game were based on the frequency of multiple types of errors, not simply omissions. In the current study, it is therefore possible that cue saliency enhanced the ability to notice cues but not to recall the content of the associated intentions, an effect that would not be captured by comparing overall scores across saliency conditions.

To determine whether cue saliency affected only the prospective component of ProM in this study, exploratory analyses were carried out on the percentage of ProM failures and loss of content errors that occurred under salient as compared to non-salient conditions within each group. The results revealed that each group made fewer omissions (ProM failures) when cues were salient versus non-salient, despite an overall greater number of ProM failures by the TBI group across saliency conditions as compared to controls. By contrast, loss of content errors were made with similar frequency across cue saliency conditions in both groups. Therefore, the findings support Cohen et al.’s (2001) assertion that cue saliency is beneficial for the prospective component of ProM only.

Comments by four participants with TBI that “it (the word) is red so I must have to do something” are also consistent with this idea. Cues printed in upper-case and red font may have reduced the frequency of ProM failures by causing involuntary orienting of attention to the cue (McDaniel & Einstein, 1993) and noticing of the cue (Cherry & LeCompte,
1999). Consequently, this would reduce the need for self-initiated monitoring of the cue (McDaniel & Einstein, 2000). Cue saliency may also have triggered memory that something needed to be done (Brandimonte & Passolonghi, 1994; McDaniel & Einstein, 1993). When a cue is salient, remembering that something has to be done may rely on automatic rather than strategic processes because individuals are able to notice cues even under divided attention conditions (McDaniel & Einstein, 2000). The failure of salient cues to enhance memory for the content of intended actions suggests that, even if distinctive cues help people with TBI to remember that something needs to be done, they may not necessarily facilitate the execution of intentions if the retrospective memory load of the task is too elevated, consistent with Einstein and McDaniel’s (1990) Notice + Search model. Therefore, perceptually distinctive cues may be particularly beneficial when the response required in a particular situation is easy to remember, either because it is routine (e.g., taking medications) or because it is highly associated with the cue (e.g., mailing a letter upon seeing a mailbox). Of note, an impact of cue saliency was observed despite the fact that the cue monitoring demands of the NYW game were relatively easy compared to studies where a few cues could be introduced at any point during an ongoing task.

**Effect of Implementation Intentions on Prospective Memory**

The hypothesis that forming implementation intentions would enhance ProM performance in the TBI group compared to other encoding conditions was not supported. The TBI group performed less well than the control group on the PROAS regardless of whether they (1) simply listened to a description of the intention to be carried out and its
context, (2) listened to this information and then repeated what action had to be performed, or (3) listened to the information and then repeated what action had to be performed and under what circumstances.

Comparison of the demands of the PROAS with the task demands involved in implementation intention studies suggests that three differences in study design may have contributed to the lack of benefit derived from the formation of implementation intentions. First, the delay interval between the formation of implementation intentions and the execution of the intended action was filled with the formation and execution of other intentions. The introduction of new tasks between the formation and execution of intentions was cited as a potential reason for the absence of implementation intention effects in the study by Einstein et al. (2003). Second, participants had to carry out 15 different and relatively complex intentions. By contrast, previous investigations required the formation of only one implementation intention to carry out a single type of goal-directed behaviour that was simpler (i.e., usually a key press). Thus, the large number of cues and intentions in the current study may have increased task complexity, another variable purported to contribute to the absence of beneficial implementation intention effects (Einstein et al., 2003). Furthermore, as described by Gollwitzer (1993, 1999), the formation of an implementation intention increases the activation level of the mental representation of the anticipated situation in which to carry out an intended action. It is possible that such a representation may not be as salient if there are several highly activated situations (cues) linked with different intended actions. In turn, when the situation subsequently occurs, it may be less likely to automatically lead to initiation of
the action. A third difference between this study and previous investigations of implementation intentions concerns the mixed design employed. Indeed, each participant was exposed to all three encoding instructions, whereas participants in previous studies each received different instructions (e.g., they had to form implementation intentions either for the target activity or for another action). It is therefore possible that participants in the current study did not always follow the instructions pertaining to the encoding condition specified. For example, three participants from the TBI group were noted to respond to implementation intention cards with a response reflecting the active control condition. There was also no control over whether or not the full instructions, including visualization of the situation, were carried out. The similarity and relative complexity of the active control and implementation intentions instructions may have been confusing for some participants. Further research would be required to disentangle the potential contribution of each of these factors to the lack of implementation intention effects.

**Other Cognitive Functions and Their Associations with Prospective Memory**

Secondary analyses revealed that group differences on tests of working memory (Digit Span Backward) and delayed recall (RAVLT) were accounted for by depressive symptomatology, with similar group performance after statistically controlling for BDI-II scores. By contrast, the TBI group had significantly more difficulty than the control group with the cued recall of intentions and cues associated with both ProM tasks.

The primary purpose of administering the RAVLT in the current study was to assess the contribution of retrospective memory to ProM performance in people with TBI. Findings regarding the relationship between retrospective memory and ProM have been
inconsistent, with correlations between delayed recall and ProM depending on the study and on the task used (e.g., correlations of ProM with the RCFT, CVLT-II and Visual Reproduction II, inconsistent association with Logical Memory II and the WMS-R delayed recall index) (Groot et al., 2002; Kopp & Thöne-Otto, 2003; Knight et al., 2006; Schmitter-Edgecombe & Wright, 2004). The expectation that measures of ProM and retrospective memory should be related stems from the fact that ProM encompasses a retrospective memory component (Burgess & Shallice, 1997; Cockburn, 1995). There is a tendency for ProM performance to show an association with retrospective memory scores when ProM paradigms place greater demands on the content of intentions instead of requiring a single response (e.g., pressing the “/” key) to all cues presented.

In the current study, the number of correctly recalled intentions on ProM tasks was predicted to be related to performance on the RAVLT because of the high load placed on the content of intentions within the NYW game and the PROAS. Contrary to prediction, performance on the ProM tasks was not related to RAVLT scores for immediate recall in the TBI group and only the PROAS was related to delayed retrospective recall. Initially, the overall lack of a significant relationship may appear surprising. However, some authors have asserted that ProM and retrospective memory are not necessarily related, with some individuals presenting with impaired ProM despite intact retrospective memory (e.g., McDaniel et al., 1999; Shallice & Burgess, 1991). Indeed, a person may perform well on a measure of retrospective memory that requires the free recall of content upon examiner request but perform more poorly on ProM tasks because of a disturbance in one or more cognitive processes related to its prospective component. In ProM tasks, recall
depends on self-initiated responding to an external cue without explicit prompting by an external agent. Thus, if an individual shows deficits restricted to the prospective component of ProM (indicated by a preponderance of ProM failures compared to other error types), this would not impact their performance on retrospective memory tasks that, by definition, lack a prospective component. Consequently, the individual’s performance on ProM and retrospective memory tasks would not be expected to be correlated (Einstein & McDaniel, 1990). In the current study, the overall weak link between scores on the RAVLT and on ProM tasks in the TBI group cannot be explained by intact retrospective memory. The TBI participants’ reduced cued recall of intentions and cues and their more frequent loss of content errors compared to controls are suggestive of retrospective memory impairment.

One potential explanation for the lack of association between scores on ProM tasks and the RAVLT trials in the TBI sample relates to the strategic monitoring and noticing of the appropriate intention-related circumstances (e.g., external cues) that needs to occur before searching for the content of the intention (Einstein & McDaniel, 1996). Thus, the lack of association may be due to the fact that the TBI group’s low scores on ProM tasks were frequently related to problems with the prospective component of ProM (i.e., a large number of ProM failures). It may be that RAVLT scores would correlate significantly with the number of loss of content errors on ProM tasks, which provides an estimate of the retrospective component of ProM. In a study by Carlesimo et al. (2004), people with severe TBI who showed a greater disturbance in the retrospective component of ProM performed less well on a test of free recall.
As mentioned, scores obtained on cued recall measures associated with the ProM tasks provide another estimate of the retrospective component of ProM. A medium positive association was found between TBI participants' lower scores on the cued recall measures and on the ProM tasks. This relationship may be due to shared processes between ProM and cued retrospective memory tasks (McDaniel & Einstein, 1993), such that both require the pairing of stimuli and the retrieval of one stimulus upon presentation of the other. It is thus plausible for ProM performance to be more closely associated with cued recall than with free recall of a series of unrelated items on the RAVLT.

The association between ProM and working memory has been less frequently investigated in TBI samples. In the current study, the number of intentions correctly recalled by TBI participants on ProM tasks showed a medium positive link to working memory based on Digit Span Backward. This finding is consistent with the relationship between performance on an event-based ProM task and on Digit Span Backward demonstrated in a sample with TBI by Schmitter-Edgecombe and Wright (2004). Based on their results, these authors suggested that lower ProM performance may have been attributable to reduced efficiency of attentional resource allocation or working memory capacity.

Reduced working memory may compromise ProM performance in multiple ways. First, as hypothesized by Kopp and Thöne-Otto (2003), a limited amount of attentional resources can reduce the resources available to monitor for cues when engaged in an ongoing activity. In the present study, however, the more challenging ProM task (the NYW game) only necessitated cue monitoring when a card was picked up. The
association between ProM and working memory may also stem from having to hold several intentions in mind simultaneously while engaging in various distractor activities during the delay period. In the current study, participants had to keep track of multiple intentions and cues, along with the requirements of the NYW game and of the PROAS. On the other hand, the requirements of the filler tasks were presumably easy to keep in mind because they involved activities that were simple (e.g., cancellation tasks) or that were familiar to participants (e.g., word search puzzles). A third manner in which working memory may contribute to ProM performance is by allowing for the rehearsal of intentions or for periodic self-reminders during the completion of filler tasks (Kliegel et al., 2000). According to Einstein and McDaniel (1996), self-reminders are necessary to strengthen the memory trace for the intention. Consequently, a working memory deficit may have resulted in less self-reminders during the ongoing tasks, and therefore in lower ProM scores. Self-reminders also rely on the ability to plan because their goal is to prepare for the fulfillment of intentions at some point in the future. Additional studies could assess the extent to which rehearsal of intentions in TBI participants (based on self-report) correlates with their ProM performance. Lastly, working memory processes are hypothesized to be required to interrupt an ongoing activity (McDaniel et al., 1999). Unlike the NYW game where participants were informed to pick up a card, the PROAS required interruption of the ongoing activities to carry out intentions.

Executive functions, such as the ability to interrupt an ongoing activity, have been reported to be more involved in time-based than in event-based ProM tasks (Cockburn, 1995). Because few studies report an association between executive functions and event-
based ProM, the status of their relationship was not assessed in this study. However, as noted earlier, planning may be necessary to engage in self-reminders of the intentions during an ongoing activity. It would be interesting to investigate the link between performance on a measure of planning and on ProM tasks. Executive functions likely play a significant role in ProM tasks in everyday life where individuals must plan and decide when and how to carry out their intentions based on their schedule and routine (Shimamura et al., 1991).

**Self-Reported Prospective Memory Functioning after TBI and Its Relationship to Objective Prospective Memory Performance**

Secondary analyses revealed that both groups reported more problems on the ProM subscale than on the retrospective memory subscale of the PRMQ. Similarly, an earlier investigation of self-reported problems with everyday memory functioning had shown that both TBI and healthy subjects complained primarily of problems with attention/ProM compared to other types of memory focusing on previous events or previously learned information (Mateer et al., 1987). The current study also revealed that the TBI group endorsed significantly more items than the control group on the ProM and retrospective memory subscales both before and after statistically controlling for depressive symptomatology. The TBI group's report of more frequent problems with remembering to perform future actions compared to controls is consistent with the results obtained by Hannon et al. (1995). The authors found that people with TBI complained more than healthy adults of problems with remembering to perform routine tasks (e.g., locking the door when leaving home). By contrast, Kinsella et al. (1996) had reported that
their TBI participants did not acknowledge more episodes of forgetting despite indicating a recent change in their memory status. However, their sample included people who had been residing in the community for a minimum of two weeks only and who may have shown reduced awareness because they had not yet resumed premorbid activities requiring a higher level of cognitive functioning. The current study suggests that participants with TBI had some insight into the impact of their memory difficulties on their daily functioning. It also implies that individuals with varying degrees of TBI severity report both ProM and retrospective memory problems that persist months to years after their injury. However, the accuracy of their report cannot be ascertained without collateral information.

Contrary to prediction, the performance of the TBI group on the NYW game and on the PROAS was not significantly related to their score on either of the PRMQ subscales. However, their ProM performance was related more strongly to complaints involving memory for things to do than for things from the past. Furthermore, the size of the correlations involving the ProM subscale ($r = -.23$ to -.38) was similar to that reported by Hannon et al. (1995) ($r = .17$ to .25) across TBI and control groups using the Prospective Memory Questionnaire and a ProM task comprised of 4 event-based and time-based items. By contrast, Groot et al. (2002) reported ProM performance to be related to family ratings of the frequency of everyday memory problems, but not to self-ratings.

Discrepancies between self-reported everyday memory functioning and objective ProM performance after TBI may be attributable to several factors. First, a reduced level of insight is unlikely to explain the lack of association between self-reported and objective
ProM performance because TBI participants did endorse significantly more problems with both ProM and retrospective memory compared to healthy adults. Second, different self-report and objective ProM measures have been employed across studies, making it difficult to compare results. The extent to which the self-report and objective measures used in a particular study refer to the same underlying construct can also impact their relationship (e.g., if the self-report measure refers only to problems with time-based ProM and objective tasks assess event-based ProM). In the current study, the PRMQ referred to activities that have to be carried out to either time- or event-based cues whereas both ProM tasks emphasized only event-based activities.

Some investigators have postulated that a link between depression and heightened memory complaints may contribute to the lack of a significant association between ProM complaints and objective ProM performance (Larrabee et al., 1986). Specifically, self-ratings of greater memory problems have been associated with higher BDI scores across both TBI and control groups (Hannon et al., 1995). In older adults, memory complaints have been more highly associated with psychological distress than with actual ProM scores (Kliegel et al., 2005). Furthermore, a study by Zeintl et al. (2006) revealed that ProM performance was compatible with self-ratings of everyday memory only in older adults with less depressive symptomatology. Although the same may hold true for individuals with TBI, heightened memory complaints in the TBI sample were not related to their objective ProM performance despite statistically controlling for BDI-II scores. The lack of a significant association between subjective and objective ProM performance is interesting given that the groups differed on both the PRMQ subscales and the ProM
tasks. As Zeint et al. (2006) pointed out, concerns regarding the adequacy of formal retrospective memory tasks as evidence for everyday memory functioning may also apply to ProM measures. Indeed, the lack of a relationship could reflect low ecological validity of the ProM tasks. The PRMQ inquires about everyday ProM failures that may not be well-measured by laboratory-based tasks despite participants' reports of similarities between the NYW game activities and their daily situations. For example, it may be that the NYW game emphasized primarily strategic monitoring processes whereas many everyday ProM situations may be supported by relatively automatic retrieval processes, as argued by Einstein et al. (2005). Other differences between the ProM demands in daily life and in laboratory-based tasks will be highlighted in the next section.

Limitations of the Present Study

The results of this dissertation should be interpreted in light of the following considerations: (1) nature of the sample, (2) methodological shortcomings, and (3) theoretical underpinnings of ProM. Regarding the TBI sample, it was somewhat biased to people with an interest in research studies. Furthermore, most participants with TBI had received rehabilitation services that included a cognitive or functional (occupational therapy) component. Therefore, they may have been particularly motivated to improve their cognitive skills compared to the general TBI population. Lastly, participants with TBI were mostly in the chronic stage post-injury and had recovered to an independent level of functioning. Therefore, the results derived from this study cannot be generalized to people (1) in the acute stage post-TBI (less than 6 months), (2) with very severe comprehension, retrospective memory, or working memory difficulties, or (3) with
cognitive deficits pervasive and profound enough to preclude independent living. On the other hand, the results are not generalizable to individuals with such mild TBI that medical attention was not sought.

In terms of methodological limitations, objective medical documentation of TBI severity would have provided a more valid and reliable indicator of injury severity than exclusive reliance on participants’ self-report. However, this was not feasible due to practical reasons related to time and cost. Further, most participants were well-informed about the details surrounding their injury and permission was obtained to contact a family member in two situations where the person’s self-report was unclear. The decision not to exclude participants with a psychiatric history was made so the results would be representative of the large proportion of people with TBI who experience depression. The impact of level of depression on ProM performance in the TBI group could be assessed by comparing the results obtained with and without statistically controlling for the level of depressive symptomatology. Similar results across the two types of analyses suggest that lower performance by the TBI group on many measures was not simply related to emotional factors.

Two other points are worth mentioning regarding the methodology. First, it would have been useful to compare group performance on the filler tasks to rule out potential confounding effects of filler task performance on ProM scores. Second, the rating scale assessing the frequency of use of mnemonic strategies during the PROAS did not address the key question pertaining to the encoding conditions. It would have been preferable to ask participants how well they followed the instructions pertaining to each encoding
condition because the passive encoding condition did not entail the use of mnemonic strategies.

Prospective memory is not a unitary construct (Einstein & McDaniel, 1990). Therefore, the findings of this study cannot be generalized to time-based tasks because different cognitive processes are likely involved (Glisky, 1996). Furthermore, the extent to which performance on the ProM tasks predicts the ability to remember intentions in daily life is not clear, as there are at least three major differences between the demands of ProM tasks and daily life. First, the delay between the formation and the execution of intentions was relatively short compared to the days, weeks, or even months that may separate the formation and retrieval of intended actions in everyday situations. Second, cues and intentions were imposed by the examiner. In everyday life, intentions are often self-imposed based on our needs and may involve routine actions such as mailing a letter or taking medications (Cohen & O’Reilly, 1996). Lastly, intentions had to be carried out in response to precise external cues compared to some instances in daily life where we may intend to perform actions at some relatively undetermined point in the near future (e.g., returning a friend’s call “this week”). Notwithstanding these differences, the NYW game appears to approximate daily task demands more closely than most other ProM measures described in the TBI literature (e.g., computer tasks involving a key press), with the exception of the virtual shopping task developed by Knight et al. (2006).

Clinical Implications

This study adds to a growing body of literature suggesting that individuals with TBI tend to forget to carry out their intentions, over and beyond what can be accounted for
by psychological factors. Indeed, the large effect sizes obtained, particularly on the NYW game, indicate that ProM difficulties may be clinically significant after a TBI. However, the lack of group differences on the PROAS when it was given as the second ProM task suggests that people with TBI are able to perform better on ProM tasks under certain circumstances, possibly when more automatic processes are recruited depending on the parameters of the ProM situation. The results of this dissertation further suggest that ProM deficits may be present after a TBI regardless of injury severity, although further studies are needed to confirm the presence of ProM deficits after mild TBI given the small sample size.

The NYW game proved to be a more sensitive measure of memory difficulties than a traditional test of retrospective memory (the RAVLT), with relatively minimal overlap between the distribution of scores within each group. The TBI group’s significant impairment on ProM measures and the fact that their ProM complaints exceeded those of healthy adults and were more pronounced than their retrospective memory concerns suggests that neuropsychologists should routinely assess the status of ProM in individuals with TBI. The assessment of ProM may be particularly important in medical-legal cases where an individual’s report of everyday memory problems may not be corroborated by their performance on traditional retrospective memory tests. It may be that memory deficits would be uncovered if a ProM measure was also administered.

Nevertheless, there are currently no standardized, valid and reliable tools to assess ProM in individuals with TBI seen in clinical settings. The results of this dissertation suggest that the NYW game has the potential to become such a tool. It has high inter-rater
reliability and internal consistency. Unlike most of the ProM tasks described in the TBI literature, the NYW game simulates having to juggle multiple, simultaneous intentions pertaining to daily life. Participant ratings suggest a relatively strong parallel between the activities to remember within the NYW game and daily intentions. Informal participant comments also reflect the high face validity of the game. For example, three participants who obtained particularly low scores spontaneously commented that (1) remembering to do things like turning off the oven is “a big problem”, (2) their house is “full of sticky notes”, (3) they “forget stuff like this in real life”, and (4) “this is what happens all the time: I want to do something, then I forget right away.” Another advantage of the NYW game over several of the existing ProM tasks relates to its format. Most participants with TBI claimed to have found the game “fun”, including people who obtained very low scores. None of the participants appeared distressed over their performance. This is likely because several intentions had to be kept in mind simultaneously, thereby making it difficult for participants to keep track of their level of performance. The NYW game showed good convergent validity in the TBI group, being highly correlated with another task designed to assess ProM, with measures of retrospective cued recall, and with a test of working memory. Lastly, ceiling and floor effects were not prominent, with a wide distribution of scores across TBI participants. This task may best assess the status of ProM in situations requiring more strategic monitoring processes such as when people have to notice a cue that is not central to their current attentionally-demanding activity (e.g., remembering to mail an envelope that is sitting on their desk when they finish doing their online banking).
Difficulties carrying out intentions is often a prime target in TBI rehabilitation. The NYW game could be used in rehabilitation settings to evaluate the need for ProM aids. It could also help to identify whether difficulties lie in the prospective or retrospective component of ProM. Analysis of the types of errors made by a person with TBI could be used as a starting point to identify the type of external aid best suited to that person’s needs. For example, some individuals may benefit from prosthetic memory devices that simply cue them that something needs to be done (e.g., a simple alarm); others may require more extensive systems that also remind them of the action that needs to be carried out or that keep track of previously carried out intentions. The NYW game could also identify whether an individual has a tendency to become confused when several similar actions had to be carried out. Knowledge of a person’s susceptibility to task substitutions or interference in general is important so that the individual is not given too many similar tasks to do within a short time frame. For example, if asked to buy milk at the grocery store and fresh bread at the bakery, the person may end up buying both milk and regular bread at the grocery store.

The NYW game could serve to assess the extent to which a person with TBI is able to benefit from salient cues. If cue saliency does help someone to remember that they have to do something, cues linked to particular tasks could be made more salient in a person’s home environment. For example, pills to be taken with breakfast could be placed in a large bright container next to the cereal box instead of remaining in a small pill bottle. However, if difficulties with the retrospective aspect of ProM are also prominent, a reminder of the content of the intention would also be necessary. Therefore, the container
of pills would have to indicate when and how many pills to take. Another example would be for a person to have a bright-coloured magnet on their refrigerator to serve as a reminder of something to do (e.g., a bright red telephone-shaped magnet placed there to remind the person that a call has to be made). However, nothing else would have to be posted on the refrigerator because cue distinctiveness is defined against the background in which the cue appears (McDaniel & Einstein, 1993). Cue saliency would not be helpful in situations where environmental modifications cannot be made or when tasks have to be performed at a particular time.

Directions for Future Research

The results of this study are interesting in that they suggest that ProM deficits may be a prominent neuropsychological feature post-TBI. Such deficits are not fully accounted for by symptoms of anxiety and depression and may occur regardless of TBI severity. In addition to the few ideas already raised with respect to future research, the results point to several issues that require further clarification. First, it would be worthwhile to investigate whether the effects of cue saliency on the prospective component of ProM would diminish over time due to habituation. It seems possible that an item that was made salient in one’s home in order to “notice” it and carry out an intention would no longer stand out after a few days or weeks. Second, investigation of the effects of implementation intentions after TBI should still be pursued because the failure of participants to benefit from this strategy may be related, at least partly, to the repeated measures design, and a future study could instead employ a between-group design to minimize any confusion between instructions. Fewer items could be given, as in
previous studies on implementation intentions. Lastly, it would be interesting to assess the effects of reminders on performance on the NYW game, and, specifically, to determine whether a particular type of reminder (e.g., referring to the cue, the intention, or their association) may be effective in helping people with TBI carry out their intentions.
References


Clinical and Experimental Neuropsychology, 28(4), 536-548.


Gollwitzer, P. M., & Brandstätter, V. (1997). Implementation intentions and effective goal


Lengfelder, A., & Gollwitzer, P. M. (2001). Reflective and reflexive action control in
patients with frontal brain lesions. *Neuropsychology, 15*(1), 80-100.


Appendix A: List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>BADS</td>
<td>Behavioural Assessment of the Dysexecutive Syndrome</td>
</tr>
<tr>
<td>BAI</td>
<td>Beck Anxiety Inventory</td>
</tr>
<tr>
<td>BDI-II</td>
<td>Beck Depression Inventory-II</td>
</tr>
<tr>
<td>COWAT</td>
<td>Controlled Oral Word Association Test</td>
</tr>
<tr>
<td>CVLT</td>
<td>California Verbal Learning Test</td>
</tr>
<tr>
<td>GCS</td>
<td>Glasgow Coma Scale</td>
</tr>
<tr>
<td>NAART</td>
<td>North American Adult Reading Test</td>
</tr>
<tr>
<td>NYW</td>
<td>Navigating Your Week</td>
</tr>
<tr>
<td>PCSC</td>
<td>Postconcussive Syndrome Checklist</td>
</tr>
<tr>
<td>ProM</td>
<td>prospective memory</td>
</tr>
<tr>
<td>PROAS</td>
<td>Prospective Remembering of Actions and Sentences</td>
</tr>
<tr>
<td>PRMQ</td>
<td>Prospective and Retrospective Memory Questionnaire</td>
</tr>
<tr>
<td>PTA</td>
<td>post-traumatic amnesia</td>
</tr>
<tr>
<td>RAVLT</td>
<td>Rey Auditory Verbal Learning Test</td>
</tr>
<tr>
<td>TBI</td>
<td>traumatic brain injury</td>
</tr>
<tr>
<td>WCST</td>
<td>Wisconsin Card Sorting Test</td>
</tr>
<tr>
<td>WMS-R</td>
<td>Wechsler Memory Scale-Revised</td>
</tr>
</tbody>
</table>
Appendix B: Demographics Screener

Participant number: __________

Date: __________

1. Sex: Male  Female

2. Age: _______ (Must be between 18-55)  DOB: __________

3. Years of education: __________
   a) What was the last grade you completed? ______
   b) Did you attend college or university? ______ For how many years? ______
   c) What type of degree did you obtain? __________

4. Do you have vision problems not corrected by glasses? _______ Y  N

5. Do you have hearing problems not relieved by a hearing aid? _______ Y  N

6. Do you have any problems using your hands? _______ Y  N

7. Do you have any neurological conditions? (Other than TBI for that group) _______ Y  N
   Please specify: __________

8. Do you have other health-related problems (e.g., diabetes, heart disease)? _______ Y  N
   Please specify: __________

9. Have you ever been diagnosed with a learning disability? _______ Y  N

10. Did you have problems learning in school? _______ Y  N

11. Do you experience any pain? _______ Y  N

   How bad is it on a scale from 0 to 10? __________

12. Are you currently employed or are you in school? _______ Y  N

   What is your occupation: __________

13. (TBI only) Were you working or a student at the time of your injury? _______ Y  N

   What was your occupation: __________
Appendix C: Demographics Questionnaire

Participant number: ______

In order to better understand the results of my study, I need to know a few things about you and your background. I will use this information for research purposes only and it will be kept strictly confidential. However, you are not obligated to respond if you would prefer to not answer certain items.

1. What is your ethnic background: (Please circle one)
   Caucasian
   Asian
   African-American
   Native Canadian
   Other (Please specify) _______________________

2. Is English your native language? ........................................... Y  N
   If not, what is your native language? __________
   When was English learned? _______________________

3. Do you have any psychiatric conditions? (Please specify) ............. Y  N
   _______________________

4. What medications are you currently taking?
   _______________________

5. Have you ever had a neuropsychological assessment? .................. Y  N

6. Do you drink alcohol? .......................................................... Y  N
   Did you ever? ____
   How many drinks do you have per week? __

7. Do you use drugs? ............................................................ Y  N
   Did you ever? ____
Appendix D: Injury-Related Variables Survey

Participant number: ___________ Date of screening: ___________

1. Date of injury (month/year): ___________ (Must be at least 6 months ago) ___________

2. What was the cause of your head injury? (Circle one)
   - Motor vehicle accident
   - Pedestrian accident
   - Bicycle accident
   - Industrial
   - Assault / Fall
   - Other (Please describe) ________________________________

3. Were you hospitalized or did you see a doctor for your brain injury? ............ Y    N
   When? ___________ For how long? ___________

4. Did you lose consciousness at the time of injury? ....................... Y    N
   For how long were you unconscious? __________________________

5. Did you have a CT scan? ............................................ Y    N
   What were the results? ________________________________

6. Was your skull fractured? ............................................ Y    N

7. Medical documentation of the injury (e.g., Ambulance, ER, CT, MRI reports) .. Y    N

8. Is there a period of time following the injury for which your memory is poor? .... Y    N
   For how long? ___________

9. Did you receive rehabilitation services following your injury? ............... Y    N
   For how long? ___________

10. Are you currently in litigation (involved in any legal claim regarding the injury)? . Y    N

11. Have you had any other head injuries? How many? ....................... Y    N
Appendix E: Prospective and Retrospective Memory Questionnaire (PRMQ)

ID

The following questions refer to minor memory mistakes that everyone makes from time to time. Please read each question and circle the number that corresponds to how often each situation has happened to you.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Quite often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Do you decide to do something in a few minutes’ time and then forget to do it?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Do you fail to recognize a place you have visited before?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Do you fail to do something you were supposed to do a few minutes later even though it’s there in front of you, like take a pill or turn off the kettle?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Do you forget something that you were told a few minutes before?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Do you fail to recognize a character in a radio or television show from scene to scene?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Do you forget to buy something you planned to buy, like a birthday card, even when you see the shop?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>Do you fail to recall things that have happened to you in the last few days?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Do you repeat the same story to the same person on different occasions?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Do you intend to take something with you, before leaving a room or going out, but minutes later leave it behind, even though it’s there in front of you?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Never</td>
<td>Rarely</td>
<td>Sometimes</td>
<td>Quite often</td>
<td>Very often</td>
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<td>---</td>
<td>---------------------------------------------------------------------------</td>
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<tr>
<td>11</td>
<td>Do you mislay something that you have just put down, like a magazine or glasses?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>Do you fail to mention or give something to a visitor that you were asked to pass on?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13</td>
<td>Do you look at something without realizing you have seen it moments before?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14</td>
<td>If you tried to contact a friend or relative who was out, would you forget to try again later?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15</td>
<td>Do you forget what you watched on television the previous day?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16</td>
<td>Do you forget to tell someone something you had meant to mention a few minutes ago?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix F: Postconcussion Syndrome Checklist

ID ___________________________  Date __________________

Please rate the frequency, intensity and duration of each of the following symptoms based on how they have affected you today according to the following scale.

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>INTENSITY</th>
<th>DURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1= not at all</td>
<td>1= not at all</td>
<td>1= not at all</td>
</tr>
<tr>
<td>2= seldom</td>
<td>2= vaguely present</td>
<td>2= a few seconds</td>
</tr>
<tr>
<td>3= often</td>
<td>3= clearly present</td>
<td>3= a few minutes</td>
</tr>
<tr>
<td>4= very often</td>
<td>4= interfering</td>
<td>4= a few hours</td>
</tr>
<tr>
<td>5= all the time</td>
<td>5= crippling</td>
<td>5= constant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>INTENSITY</th>
<th>DURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Thank you for your time and effort in the completion of this form.
Appendix G: Rating Scales

Navigating Your Week game: Parallel with Everyday Situations

How much did the tasks resemble situations you might have to remember in your daily life?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Different</td>
<td>Slightly similar</td>
<td>Moderately similar</td>
<td>Extremely similar</td>
</tr>
</tbody>
</table>

Effort on ProM Tasks (identical for each ProM task)

How motivated were you to do well on the task?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>A little</td>
<td>Much</td>
<td>Very much</td>
</tr>
</tbody>
</table>

Prospective Remembering of Actions and Sentences task: Use of Mnemonics

How often did you use a strategy (like rehearsal or visualization) to help you remember what to do during the task?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Never used</td>
<td>Sometimes used</td>
<td>Often used</td>
<td>Used every time</td>
</tr>
</tbody>
</table>