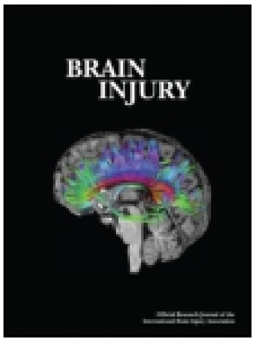

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Effective occupational therapy intervention with adults demonstrating agitation during post-traumatic amnesia

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Abstract

Objective: To investigate the effectiveness of occupational therapy (OT) with adults demonstrating agitation and post-traumatic amnesia (PTA) following brain injury.
Design: Single-system experimental design (ABAB) across subjects.
Methods: Eight subjects were recruited during acute rehabilitation. Current OT intervention was alternated with the experimental Perceive, Recall, Plan and Perform (PRPP) System approach over 4-weeks. Therapy was conducted daily. Information processing capacity during occupational tasks was measured using the PRPP System of Task Analysis. PTA status was monitored with the Westmead PTA Scale.
Experimental intervention: The PRPP System is a dynamic assessment and intervention approach that directly links results of cognitive task analysis with strategies for intervention. PRPP Intervention adopts an information processing approach that simultaneously focuses on task training, strategy training and strategy application within occupational performance.
Results: Seven subjects significantly improved in their application of processing strategies during the PRPP Intervention in comparison to current OT Intervention phases. Large treatment effects favoured the PRPP Intervention. Subjects demonstrated improved information processing strategy use both prior to and following emergence from PTA.
Conclusions: Occupational therapy intervention based upon the PRPP System of Task Analysis and Intervention improved subjects' ability to apply information processing strategies during occupational performance when compared to current intervention approaches.

Keywords: *Agitation information processing, occupational therapy, post-traumatic amnesia*

Background

Difficulty processing information from the environment and learning from it affects the occupational performance of people with head injuries [1]. Occupational performance is based upon the interaction between people and their environments, with effective performance thought to be supported by a number of cognitive capacities [2]. Of particular relevance to this study is the application of cognitive information processing strategies that support everyday task performance. These can include attending, perceiving, recognizing, remembering, judging, learning, knowing and problem-solving. Cognitive capacity also contributes to self-regulation of emotions, mood, affect and rationality during task performance [2, 3].

Various conceptual and philosophical views about the recovery of cognitive function after brain injury have led to differing approaches to cognitive intervention [4]. Occupational therapy has focused on application of two broad intervention typologies. First, the majority of therapists use a task training approach consisting of systematic instruction in a sequence of steps leading to functional outcomes in specific tasks [5]. This approach, while effective

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in achieving skill acquisition of selected tasks during the rehabilitation phase of intervention, has often resulted in limited generalization to functional performance in more open environments [6]. Secondly, therapists have focused on training of specific cognitive strategies such as scanning, attention and organization outside the context of everyday task performance [7]. While studies indicate that this approach may lead to improvement in the targeted skill, application of the cognitive strategy to everyday task performance is poor [8]. Controversy remains about the most effective intervention approach to assist processing of cognitive dimensions of task performance, particularly in people who experience post-traumatic amnesia and agitation [9].

Description of Perceive, Recall, Plan and Perform (PRPP) Intervention

Recently, Chapparo and Ranka [10] proposed an intervention approach that deviates from the dichotomized functional vs remedial typologies, by integrating aspects of systematic instruction and information processing theory. The PRPP Intervention is a task-oriented information processing approach that simultaneously focuses on task training, strategy training and strategy application within the context of everyday performance. It is part of a dynamic system of intervention that is associated with the Occupational Performance Model (Australia) [2], which directly links the results of behavioural and cognitive task analysis with strategies for intervention [11]. It is an extension of the 'Stop Think Do' programme developed for use with children and adolescents with intellectual disability [12], self-harm tendencies, impulsivity and anger management issues [13]. Table I defines the core intervention strategies in the PRPP System of Intervention.

Patients learn to apply a sequence of processing strategies to '*Stop, Sense, Think, Do*', that is gain the required level of arousal/attention for the task (*Stop*), perceive sensory information relevant to the task (*Sense*), engage in recall or planning strategies to develop a plan of action (*Think*), then implement the plan (*Do*). Patients learn to apply these strategies to their task performance by initially observing and modelling the therapist. The role of the therapist is to act as a cognitive mediator between the patient and the task. The therapist's participation fades as the patient internalizes the strategies and applies them across a range of tasks and settings. The prompts of '*Stop, Sense, Think, Do*' (given via verbal, visual, gestural and/or physical modes) are initially used as content free 'meta-prompts' to alert patients to process information required for

Table I. Core intervention strategies in the PRPP System of Intervention: Definition.

Strategy	Definition
Intervention goal is task mastery	• Expected outcome is improved functional performance in everyday tasks required by the person's occupational roles and context. • Intervention success is therefore measured by increased functional performance.
Application of evidence based principles of systematic instruction	• Goal of intervention is clear to client. • Least to most prompt hierarchy is used. • Multiple opportunities for practice of the task and target cognitive strategy are offered and performance errors are prevented. • Learning occurs across natural contexts and tasks to promote generalization. • Feedback is specific to task mastery and the cognitive strategy that is the target of intervention.
Target descriptors (cognitive strategies) are behaviourally defined and measurable	• Descriptors required for task performance are identified using the PRPP system of task analysis (outer ring Figure 1) and their effectiveness measured before and throughout intervention.
'Chunking' of descriptors across all PRPP quadrants is planned	• Starting with 'Stops', one or two descriptors only are targeted from each processing quadrant for 'Sense' (Perceive Quadrant), 'Think' (Recall and Plan Quadrants), and 'Do' (Perform Quadrant). • Single descriptors are not used. • A line of processing required for the task mirrors the direction of arrows in the centre of the PRPP system (Figure 1).
Focus of intervention is on application of cognitive strategies (descriptors) to real world performance	• The descriptor behaviours form the central verbal, physical or visual prompts given during performance and are modelled by the therapist if required. • The patient is taught to self-instruct in the strategies.

task performance. Content free prompts have been shown to improve executive dysfunction in adults following brain injury, by enhancing monitoring of current and future goals in performance, as well as the strategies necessary to achieve them [14]. These global prompts are followed up with more specific content based behavioural prompts selected by the therapist, based on findings from the assessment component of the system. These specific prompts mirror the descriptors that have been assessed in the PRPP System of Task Analysis and are pictured on the outer ring of Figure 1.

Method

Design

An ABAB experimental design was replicated across eight subjects to compare the current occupational therapy intervention approach with the experimental, PRPP Intervention. This design enabled intensive study of each subject and their response to both intervention approaches. Treatment could be specifically tailored to the patient's needs while maintaining the controls necessary for determining the effects of treatment [15]. The clinical context in which data was collected ensured the ecological validity of the results and provided a powerful decision-making tool for evidence-based practice [16]. In a heterogeneous population such as brain injury, single-case designs are often considered the 'method of choice' when evaluating therapeutic change in individuals [17, 18]. Implementing repeated baseline and intervention phases improved the internal validity of the study by controlling for history and maturation within subjects [16, 19, 20]. This type of reversal design is particularly relevant to neurological rehabilitation [21], as the effect of natural recovery can be more clearly differentiated from the effect of intervention [22].

Target behaviours/dependent variables. The primary target behaviour, or dependent variable, was information processing capacity during occupational performance. This was measured using the PRPP System of Task Analysis [11].

Intervention/independent variable. The independent variable in this study was occupational therapy intervention. Subjects received usual occupational therapy intervention during baseline phases,

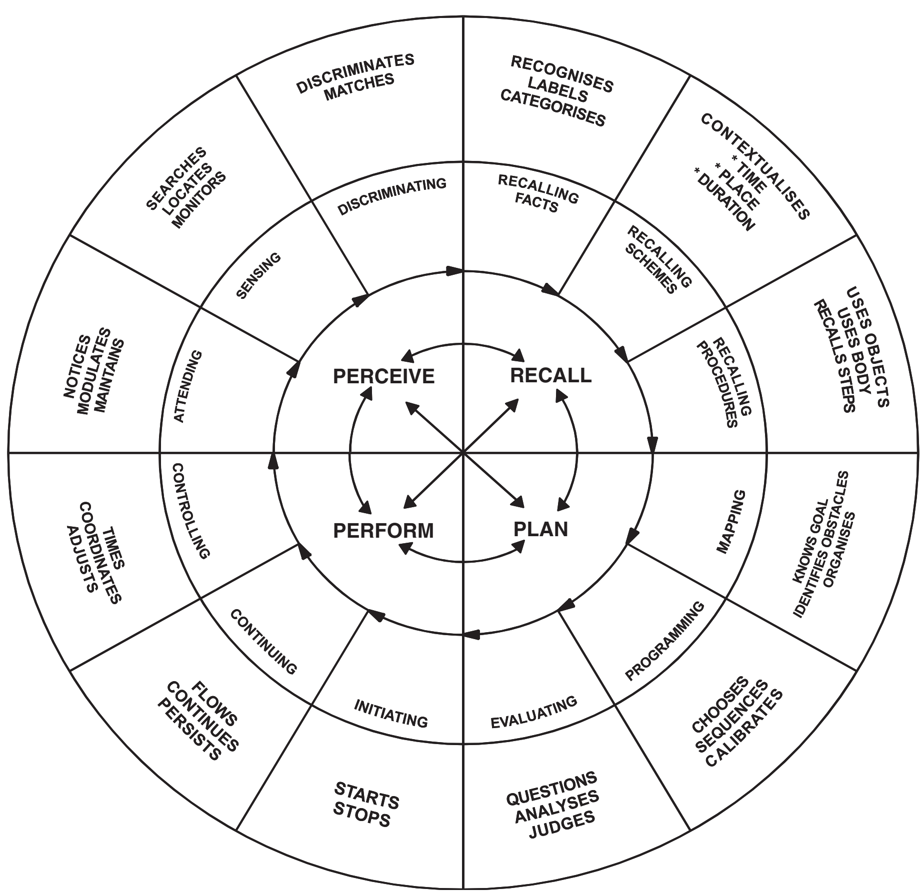

Figure 1. The Perceive, Recall, Plan and Perform System of Task Analysis.

alternating with the PRPP Intervention during the experimental intervention phases. The effect of the experimental intervention was clear if performance improved from baseline (A_1) to the first PRPP Intervention phase (B_1), reverted back to or approached baseline level of performance when this intervention was withdrawn (A_2) and improved again when the PRPP approach was reinstated in the second intervention phase (B_2) [23].

Subjects

Eight adults with brain injuries (seven traumatic brain injury (TBI); one hypoxic brain injury) participated in this study. Potential subjects were identified by clinicians and screened according to the following selection criteria: first onset brain injury; presence of post-traumatic amnesia; 17 years of age or older; admitted/referred to the brain injury rehabilitation unit (BIRU); demonstrating behaviour consistent with Rancho Los Amigos Level IV 'Confused & Agitated' or V 'Confused & Inappropriate' [24]. All adults admitted to the BIRU during the 12-month period from November 2006–November 2007 were screened. Ten patients met all the above criteria and consent was gained from next of kin. Two patients were transferred to alternate rehabilitation facilities during the study period; therefore eight subjects were included in this case series. Demographic and injury related variables for these eight subjects are summarized in Table II.

Intervention procedures

The study protocol involved four sequential phases, alternating between baseline and

Table II. Subject characteristics.

Subject	Age	Sex	CT scan/MRI results	GCS/15	Mode of injury	Recruitment (days since injury)	PTA (days)	Rancho level	Characteristic behaviours
1	35	F	DAI; Hyperdense foci in right hemisphere	8	CHI: Passenger in MVA	61	139	V	Restless, excessive response to external stimuli, poor attention, memory impairment
2	22	F	SAH; SDH; Multiple contusions; effacement of sulci	7	CHI: Driver in MVA	31	57	V	Heightened activity state, internal confusion, poor attention and memory, verbal outbursts
3	23	F	Multiple SAH; Frontal ICH; Left occipital haemorrhage	6	CHI: Driver in MVA	41	54	V	Excessive response to external stimuli, memory impairment, inappropriate responses
4	41	F	SAH with ventricular extension; facial fractures	4	CHI: Pedestrian hit by car	34	57	V	Restless, heightened activity state, memory impairment, non-purposeful behaviour
5	56	M	SAH; Right frontal contusions	3	CHI: Pushbike rider hit by car	59	U/A	IV	Aggressive, restless, responds primarily to internal stimuli, severe memory loss, confusion
6	25	M	Right frontal contusion; EDH; Fractured base of skull	3	CHI: Pedestrian hit by car	20	>60*	IV	Aggressive, restless, excessive response to internal & external stimuli, bizarre behaviours
7	47	M	Traumatic fronto-temporal lobectomy	12	Penetrating: GSW	34	57	IV	Non-purposeful behaviour, restless/wandering, fragmented responses, severe memory loss
8	24	M	Global ischaemic changes	N/A	Hypoxia	14	N/A	IV	Heightened activity state, poor attention, restless/ wandering, severe memory loss

Notes: DAI = diffuse axonal injury; SAH = sub-arachnoid haemorrhage; SDH = sub-dural haematoma; ICH = intra-cranial haemorrhage; EDH = extra-dural haemorrhage; CHI = closed head injury; GSW = gunshot wound; MVA = motor vehicle accident; N/A = assessment not performed/appropriate due to non-traumatic nature of injury; U/A = unable to assess doe to level of agitation and aggression; *Subject 7 was transferred to an alternate rehabilitation facility 60 days post-injury and remained in PTA at this time.

experimental intervention. The study period (4-weeks) was established from previous research by the authors, identifying the average duration of agitation in patients at this rehabilitation facility to be 30 days [25]. Weekly alternation between phases enabled collection of at least six data points [19] on six consecutive days within each phase and served pragmatic purposes in treatment planning within the clinical context.

Baseline intervention—current occupational therapy approach. During baseline phases, subjects received daily occupational therapy from the clinical OT. The current approach is described as functional/ compensatory with aspects of behavioural management. Therapy sessions targeted specific occupational tasks or activities selected by the clinical OT in accordance with rehabilitation goals (for example self-care, leisure, community participation, home management). Methods of intervention included systematic instruction; task adaptation; environmental modification; physical guidance; and facilitation. Intervention was conducted in each subject's hospital bedroom or bathroom, communal dining/leisure areas, ADL kitchen and local community settings, as part of a multi-disciplinary programme including medical and nursing care, physiotherapy, occupational therapy, speech pathology, clinical psychology and social work.

Experimental intervention—PRPP System. Occupational therapy was provided daily during the experimental intervention phases by the research OT (MN) using the PRPP intervention approach. The PRPP System, as outlined earlier, is a dynamic assessment and intervention approach, where intervention is based upon all stages of information processing. Intervention sessions specifically targeted learning of information processing strategies using graded prompts (verbal, visual, gestural, physical), progressing from content free metaprompts to more specific content based behavioural prompts. Patients learnt to apply 'stopping', 'sensing/attending', 'thinking' (recalling and planning) and 'doing' strategies to their performance across various occupational tasks (including self-care, leisure, home management and community integration activities).

To minimize bias and maintain internal validity, the tasks/activities targeted during the experimental intervention phases were selected by the clinical OT. Multi-disciplinary rehabilitation continued as per the baseline phase, with the frequency of intervention remaining consistent across all phases. Subjects were informed they were to have different therapists on alternate weeks, with no further information provided regarding similarities or differences in intervention procedures. Therapy sessions during the experimental phases were not observed by the clinical OT to minimize carry-over effects.

Measures

The primary target behaviour, information processing capacity during occupational performance, was measured using the PRPP System of Task Analysis. This tool forms part of the overall PRPP System of assessment and intervention. It is a criterion referenced assessment that employs task analysis methods to identify difficulties in information processing during task performance and provides a focus for intervention [11, 26]. The PRPP System of Task Analysis has demonstrated sensitivity in measuring information processing over time in a case study of severe agitation following TBI [27].

The subject receives a criterion-referenced score for 34 different information processing descriptors assessed during task performance. These descriptors are rated (3) effective for task performance, (2) questionable or (1) not effective. Ratings for each descriptor were summed and converted to a total percentage score, therefore a higher total score indicated that more effective processing strategies were being used by the subject during task performance.

Presence of post-traumatic amnesia (PTA) was an inclusion criterion of the study. PTA status was monitored daily using the Westmead PTA Scale [28]. Individuals were deemed to have emerged from PTA on the first day of scoring three consecutive scores of 12/12.

The PRPP System of Task Analysis was administered daily by the research OT, while the clinical OT or nursing staff conducted daily PTA monitoring. Phase length was set at a minimum of 6 consecutive days, with the intention to have one washout day between phases. Determining the length of baseline and experimental phases on an *a-priori* basis reduced assessor bias, thus the change from one phase to the next occurred irrespective of the research therapist's monitoring of the target behaviour. A small number of changes to phase length occurred in response to clinical decisions such as changing wards or clinical therapists.

Rater reliability

Common to single-system designs are potential methodological limitations due to observer bias [15]. In this study, the research OT completed daily measures of the target behaviour during both the baseline and experimental phases, in addition to providing the experimental intervention. Therapy sessions were videotaped to analyse intra-rater and inter-rater reliability. Approximately one-quarter of all daily therapy sessions were videotaped; not all sessions could be videotaped due to the personal nature of many therapy sessions (focusing on self-care, dressing and showering retraining).

The research OT re-assessed each performance from the videotaped data. The second set of ratings was correlated with the initial ratings to measure *intra-rater* reliability. An independent rater also observed and scored the videotaped data. These ratings were correlated with the initial ratings by the research OT to measure *inter-rater* reliability [15]. The independent observer was an OT with extensive neurological rehabilitation experience, previously trained to administer the PRPP System of Task Analysis, with no relationship to the subjects or the study.

Data analysis

Visual and statistical analyses were performed. Change in performance level between adjacent phases, latency of change and trend/slope of plotted data were determined by visual analysis [23]. Linear regression lines are overlaid to assist the interpretation of visual data.

Prior to statistical analysis serial dependency of the data was checked using autocorrelation coefficients (refer to [17], p. 173 for specific procedures). Data were not serially dependent, meaning that ANOVA assumptions were not violated. Differences between the mean values obtained in each phase of the study were analysed using ANOVA, with a p value ≤ 0.05 used to determine statistical significance. Scheffé post-hoc tests were performed to localize significant differences between means of individual study phases. The effect size was measured using partial eta squared $\left(\eta_p^2\right)$, which estimates the amount of variance accounted for in the sample due to the treatment effect and the error variance [28]. Partial eta squared is a sample based statistic and therefore more appropriate to single-system designs than omega squared (a population based estimate of effect). Effect sizes above 0.26 were considered large [29, 30].

Rater agreement was measured using a type (3,1) intra-class correlation coefficient (ICC), with random subject factor and fixed rater factor, testing for absolute agreement [31, 32]. A coefficient ≥ 0.85 was considered acceptable for intra-rater and inter-rater agreement [19].

Results

Internal validity—observer bias

Intra-rater reliability was very high, ICC (3,1) = 0.97 (95% CI: 0.94–0.99), suggesting that the research OT (MN) remained reliable over time in assessment of occupational performance using the PRPP System of Task Analysis. Level of agreement with an independent observer was examined through video analysis of one-quarter of all therapy sessions. The level of agreement, ICC (3,1) = 0.86 (95% CI: 0.73–0.93), supports the non-biased measurement procedures implemented by the research OT throughout the study.

Individual subject results

Each figure in the following series presents one subject's daily PRPP scores expressed as a percentage, over the four phases of the study (ABAB). Time in days is represented on the x-axis. Where applicable, a vertical arrow from the x-axis indicates day of PTA emergence. The treatment protocol implemented with Subject 1 was replicated with three similar subjects (2, 3 and 4); then with two more severely injured subjects (5 and 6). Replication then occurred with Subject 7 who had an open head injury from a gunshot and Subject 8 who had sustained a hypoxic brain injury.

Subject 1. Subject 1's performance slowly declined during Baseline 1 from 35% to 20% on days 5 and 6 (see Figure 2). A large increase in performance level occurred on day 7 at the start of the first PRPP intervention phase (+38%). The performance trend clearly changes from deceleration to acceleration, which is maintained over Baseline 2 and Intervention 2. An immediate drop in performance level (−24%) occurred when the PRPP intervention was withdrawn at Baseline 2, followed by steady improvements across the phase. A second increase in performance level occurred on day 19 at the commencement of Intervention 2 (+22%). Clinically significant improvement in performance occurred over time despite Subject 1 remaining in PTA for the duration of the study.

Differences in performance across phases were statistically significant ($F = 70.125$; $p \leq 0.001$; see Table III). Post-hoc examination revealed statistically significant differences between Baseline 1 and Intervention 1 ($p \leq 0.001$) and between Baseline 2 and Intervention 2 ($p \leq 0.001$). A very large treatment effect ($\eta_p^2 = 0.92$) was found with Subject 1, favouring the PRPP intervention approach.

Subject 2. During Baseline 1, Subject 2's performance fluctuated between 40–55%, achieving a stable level at 45% over days 4–6 (refer to Figure 3). Performance rapidly increased during the first Intervention phase, finishing near 80% on

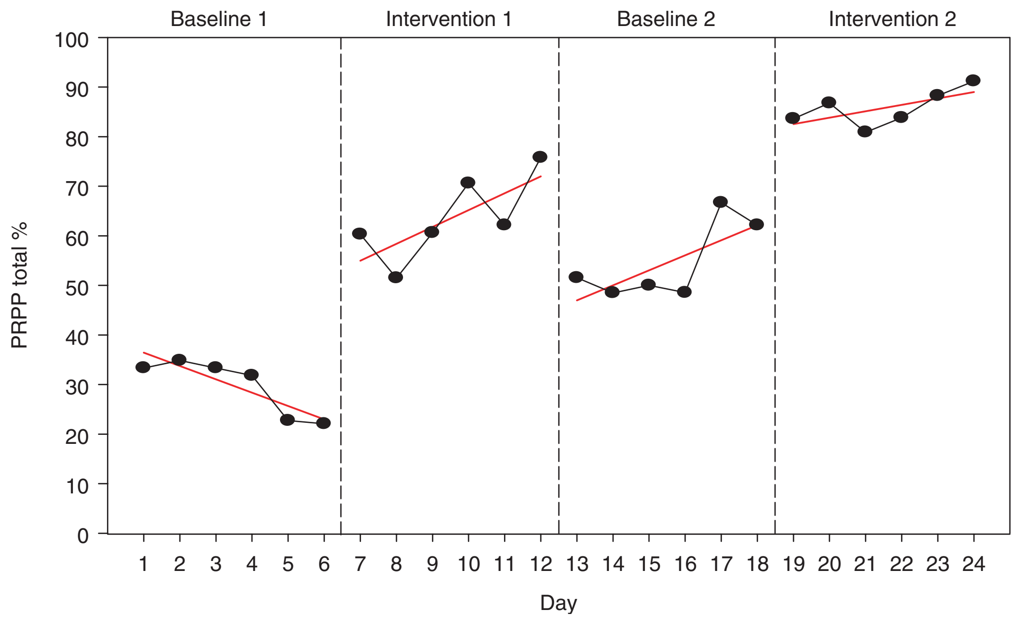

Figure 2. Subject 1—daily PRPP total % scores across each study phase.

Table III. Mean values with standard deviations for each subject across each phase, including ANOVA results and effect size.

Subject	A_1 mean	B_1 mean	A_2 mean	B_2 mean	ANOVA F statistic	ANOVA ρ	Effect size η_p^2
1	29.7 (5.7)	63.5 (8.6)	54.7 (7.8)	85.8 (3.7)	71.38	0.001	0.92
2	46.8 (5.5)	74.5 (9.3)	66.3 (6.4)	89.9 (5.9)	41.59	0.001	0.87
3	74.0 (5.9)	84.6 (5.5)	80.1 (8.6)	95.3 (1.5)	13.84	0.001	0.68
4	23.3 (7.6)	74.4 (11.6)	54.6 (21.5)	85.3 (6.8)	31.72	0.001	0.81
5	4.0 (2.8)	16.2 (15.2)	3.8 (2.8)	13.4 (10.2)	2.77	0.068	
6	24.4 (5.9)	45.3 (9.0)	36.4 (6.6)	58.3 (6.4)	23.60	0.001	0.78
7	6.7 (5.1)	51.2 (23.0)	25.5 (5.9)	80.2 (15.1)	39.19	0.001	0.82
8	12.0 (5.4)	50.0 (4.9)	34.8 (13.4)	75.9 (6.5)	68.16	0.001	0.92

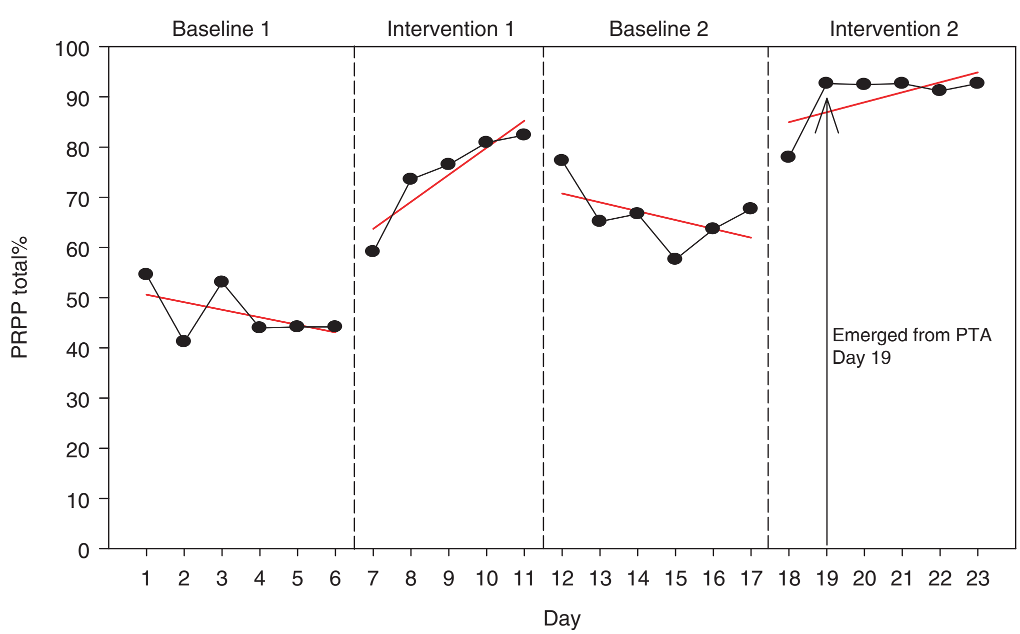

Figure 3. Subject 2—daily PRPP total % scores across each study phase.

days 10 and 11. Performance slowly dropped away from this level during Baseline 2 when the PRPP intervention was withdrawn. A trend towards improvement was seen on the final 2 days of Baseline 2. This improvement was heightened during the second PRPP intervention phase with a plateau in performance near 95%, coinciding with emergence from PTA on day 19.

Differences in performance across phases were statistically significant ($F = 52.45$; $p \leq 0.001$; see Table III). A very large treatment effect ($\eta_p^2 = 0.87$) was again evident, favouring the PRPP intervention approach. Post-hoc examination revealed statistically significant differences between Baseline 1 and Intervention 1 ($p \leq 0.001$) and between Baseline 2 and Intervention 2 ($p \leq 0.001$). The effect of withdrawing PRPP intervention between Intervention 1 and Baseline 2 did not achieve statistical significance ($p = 0.277$); however, this finding should be interpreted with caution as the trend line changed direction between these two phases, that is performance improved during the intervention phase then declined during the adjacent baseline phase; therefore even though the difference between mean values may not be statistically significant, the clinical effect of withdrawing PRPP intervention is clear.

Subject 3. Subject 3's Baseline 1 performance was high (65–80%; refer to Figure 4) even though she remained in PTA and was demonstrating behaviours consistent with Rancho Level V such as out-of-proportion responses to external stimuli, particularly auditory stimuli; confusion and confabulation of events; memory impairment; and fragmented, often inappropriate responses during conversation. These behaviours were less evident during structured, functional task performance, though remained a challenge in the ward context. Even though changes in level between phases appeared small (see Figure 4), differences between mean Total PRPP% scores were statistically significant ($F = 14.26$; $p \leq 0.001$; see Table III). Findings of the post-hoc examination revealed statistically significant differences between Baseline 1 and Intervention 1 ($p = 0.045$) and between Baseline 2 and Intervention 2 ($p = 0.002$). A large treatment effect ($\eta_p^2 = 0.68$) was found with Subject 3, favouring the PRPP intervention approach.

Subject 4. Subject 4's Baseline 1 performance improved in steps from 15–35%. A large increase in performance level (+21%) occurred on day 9 and rapidly increased during the Intervention 1 phase, finishing at 85% on days 13 and 14, to coincide with emergence from PTA (see Figure 5). A large and immediate decrease in performance level occurred on day 15 at the start of Baseline 2, followed by a series of fluctuations between 25–79% over the remaining 5 days of Baseline 2. Performance increased consistently over the second PRPP intervention phase. These large changes in performance level between phases contributed to a statistically significant difference between phases ($F = 31.17$; $p \leq 0.001$) and a very large treatment effect in favour of the PRPP intervention ($\eta_p^2 = 0.81$).

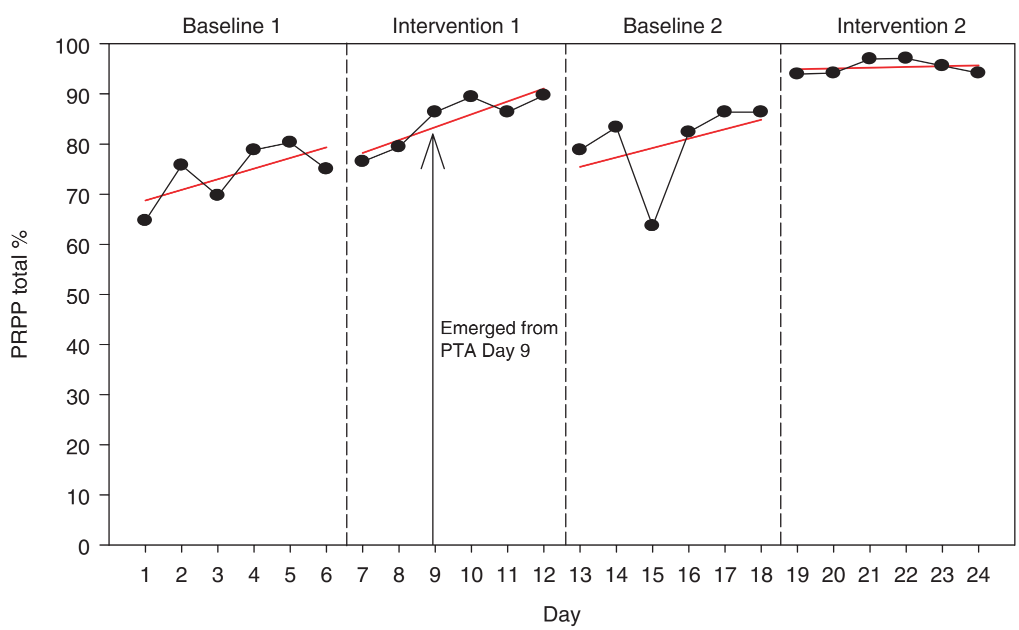

Figure 4. Subject 3—daily PRPP total % scores across each study phase.

Findings of the *post-hoc* examination reiterated findings from Subjects 1, 2 and 3, revealing a statistically significant difference between Baseline 1 and Intervention 1 ($p \leq 0.001$) and between Baseline 2 and Intervention 2 ($p \leq 0.001$).

Subject 5. The promising results observed with Subjects 1–4 prompted replication of the protocol with two more severely injured adults. As can be seen in Figure 6, Subject 5 demonstrated the lowest levels of functional performance throughout the study, with Total PRPP% scores between 0–45%. He remained confused and in PTA throughout the study but was not formally tested due to his extremely agitated response to daily testing. Visual interpretation of data across study phases suggested highly stable baseline phases (both Baselines 1 and 2) with an accelerating trend during both PRPP intervention phases (Interventions 1 and 2). Due to the *a-priori* determined phase length, the upward trend at the end of each PRPP intervention phase was not investigated further. The change in performance level between Baseline and adjacent Intervention

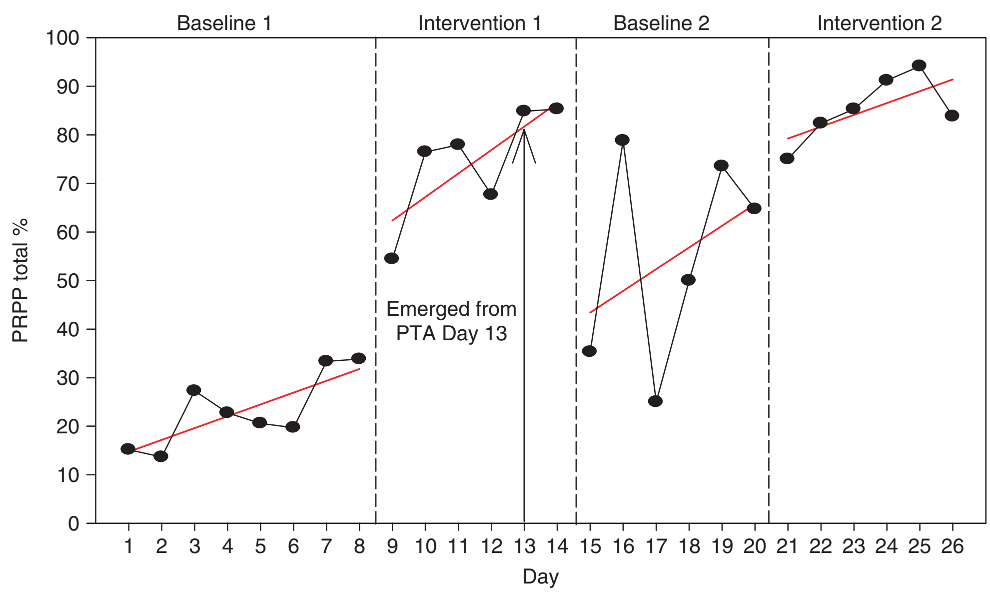

Figure 5. Subject 4—daily PRPP total% scores across each study phase.

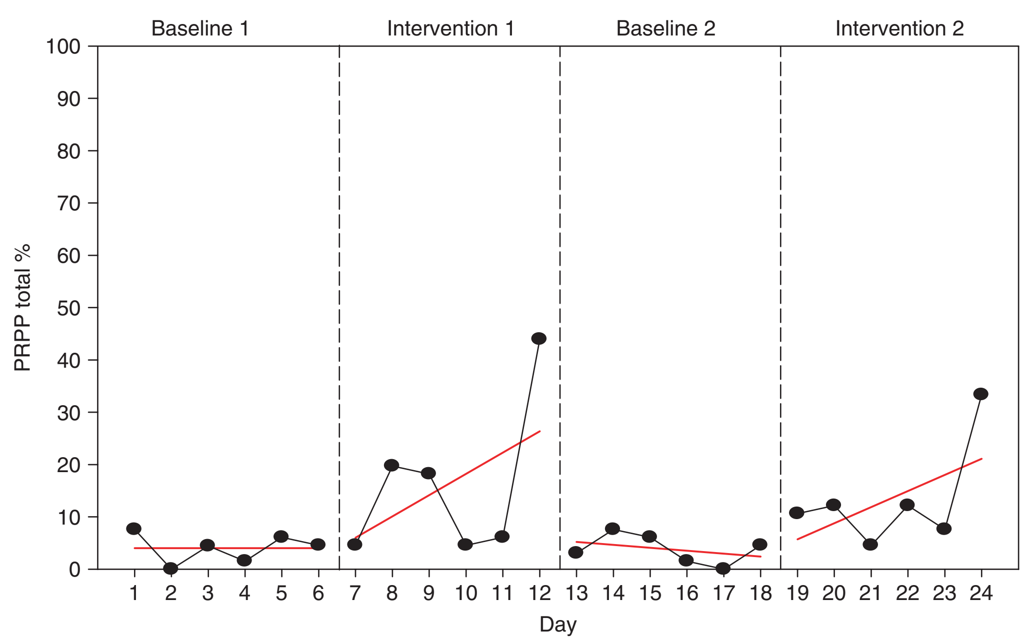

Figure 6. Subject 5—daily PRPP total % scores across each study phase.

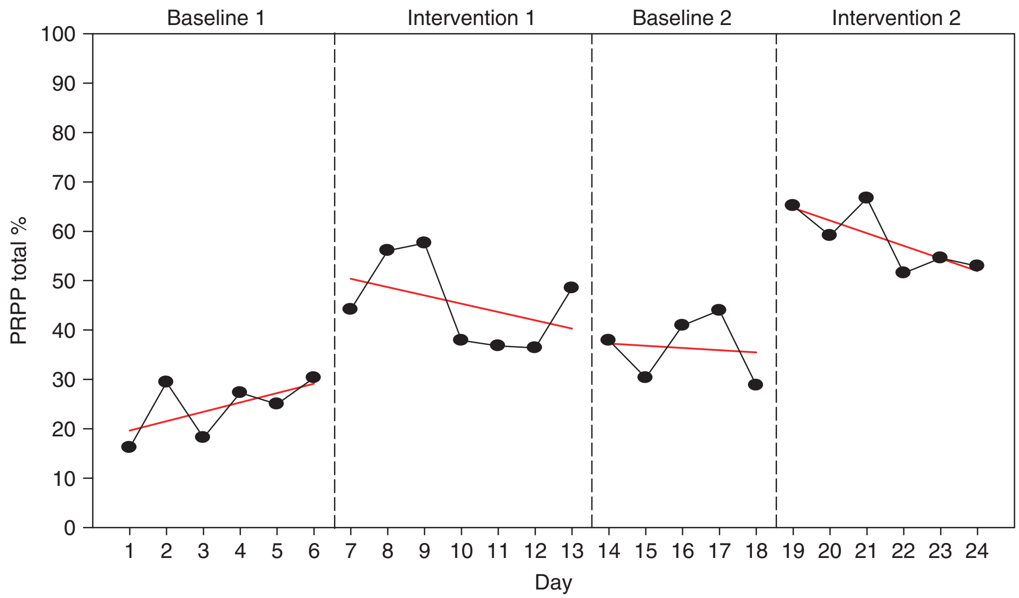

Figure 7. Subject 6—daily PRPP total% scores across each study phase.

phases was minimal. The effect of withdrawing the PRPP Intervention on day 13, at the start of Baseline 2, is quite clear. A drop in performance level by −41% can be seen in Figure 6. The differences between means of Baseline and Intervention phases were not sufficient to reach statistical significance (refer to Table III), however a trend towards improvement was evident on the final day of both PRPP intervention phases, suggesting a clinically important deviation away from the baseline that could be further investigated with longer intervention phases.

Subject 6. Subject 6's performance slowly increased during Baseline 1 from 16–30%. A jump in performance level can be seen in Figure 7 on day 7 when the PRPP intervention was introduced (+14%). Performance continued to improve during the first few days of Intervention 1 then dropped to ~37% before rising again on the last day of Intervention 1. This variable performance continued during Baseline 2, with an initial drop in performance level (−10%) and fluctuations in performance. A large increase in performance level occurred on day 19 at the commencement of the second PRPP Intervention phase (+36%), which was again followed by fluctuating performance across the phase. Large within-phase variation resulted in negative trend lines across the final three phases of the study. In spite of these variations in performance level *within* phases, the difference *between* phases was statistically significant ($F = 24.13$; $p \leq 0.001$). Post-hoc measures revealed statistically significant differences between Baseline 1 and Intervention 1 ($p = 0.001$) and between Baseline 2 and Intervention 2 ($p = 0.001$). A very large treatment effect ($\eta_p^2 = 0.78$) was found with Subject 6, favouring the PRPP intervention approach.

Subject 7. Replication attempts then concentrated on subjects that were different to the preceding subjects, all of whom had sustained closed head injuries resulting from MVAs. In contrast, Subject 7 had sustained an open head injury from a gunshot and was initially managed on an acute surgical ward due to complications with the wound. The protocol was slightly modified for Subject 7 (refer to Figure 8). Baseline 1, Intervention 1 and the first 6 days of Baseline 2 were all conducted whilst Subject 7 remained in the acute ward setting. He was then transferred to the BIRU on day 19 and the protocol was modified to have an extended Baseline 2 period in order to collect 6 days of Baseline data in the BIRU prior to commencing Intervention 2. This ensured internal validity of comparing adjacent Baseline and Intervention phases within the same treatment context, i.e. acute and rehabilitation settings.

Subject 7's performance during Baseline 1 slowly accelerated from 0–13%. Performance then rapidly increased during Intervention 1, achieving performance scores of 76%. A large drop in performance level (−44%) occurred on day 13 when the PRPP intervention was withdrawn for Baseline 2. Minimal variation in performance was observed during

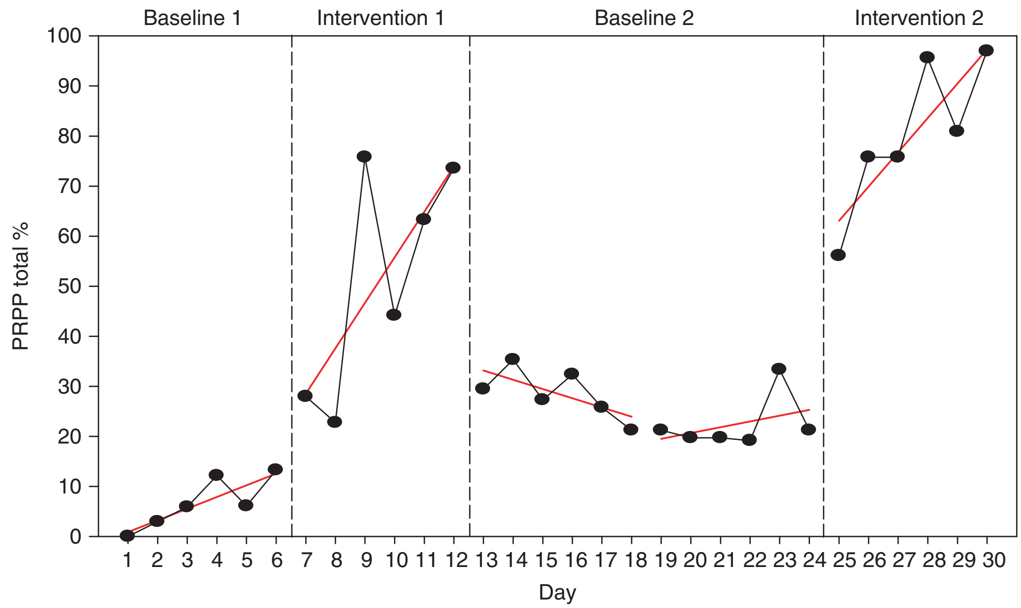

Figure 8. Subject 7—daily PRPP total % scores across each study phase.

Baseline 2, with performance scores ranging from 20–33% during both the acute and rehabilitation phases of Baseline 2. The performance level rapidly increased (+35%) at the start of Intervention 2 when the PRPP intervention was reintroduced. Subject 7 demonstrated a very strong response to the PRPP intervention approach in comparison to usual therapy, with a very large effect size ($\eta_p^2 = 0.82$).

Differences between the mean values of phases were statistically significant ($F = 39.51$; $p \leq 0.001$). Post-hoc measures revealed statistically significant differences between all adjacent treatment phases: Baseline 1 and Intervention 1 ($p \leq 0.001$), Baseline 2 and Intervention 2 ($p \leq 0.001$) and Treatment 1 and Baseline 2 ($p = 0.005$), the later highlighting the statistically significant effect of withdrawing the PRPP intervention.

Subject 8. Replication with non-TBI was then attempted. Subject 8 sustained a hypoxic injury secondary to cardiac failure. In contrast to all the preceding subjects who were managed in a highly specialized BIRU for all or part of the study period, Subject 8 remained in an acute cardiac ward for the duration of the study. In this case, Baseline intervention represents current occupational therapy intervention within the context of a general ward environment.

Visual analysis of Subject 8's performance (see Figure 9) indicates large changes in performance level between phases. A 29% increase in performance level occurred on day 7 when the PRPP intervention was first introduced. Subject 8's performance remained consistently high during Intervention 1. His performance level clearly dropped (−38%) on day 13, at the start of Baseline 2, and again increased on Day 18 (+39%) when the PRPP Intervention was reintroduced. Performance was more variable during the final two phases with gradual improvement evident on the second Baseline and a downward trend evident during the final PRPP intervention phase. These large changes in performance level between phases were statistically significant ($F = 67.87$; $p \leq 0.001$) and produced one of the largest treatment effects of all subjects ($\eta_p^2 = 0.92$) in favour of the PRPP intervention approach.

As seen with the previous subject, this large treatment effect size was associated with significant differences between all adjacent phases in the study. Post-hoc measures on Subject 8's data identified statistically significant differences between Baseline 1 and Intervention 1 ($p \leq 0.001$), Baseline 2 and Intervention 2 ($p \leq 0.001$) and Treatment 1 and Baseline 2 ($p = 0.041$).

Discussion

The results of this case series provide initial evidence for the immediate effectiveness of the PRPP System of Intervention during everyday performance of confused, agitated adults following severe brain injury. In eight cases, information processing strategies essential for daily occupational performance were identified and measured using the PRPP System of Task Analysis. Assessment findings directed the implementation of information processing strategies across a variety of occupational tasks.

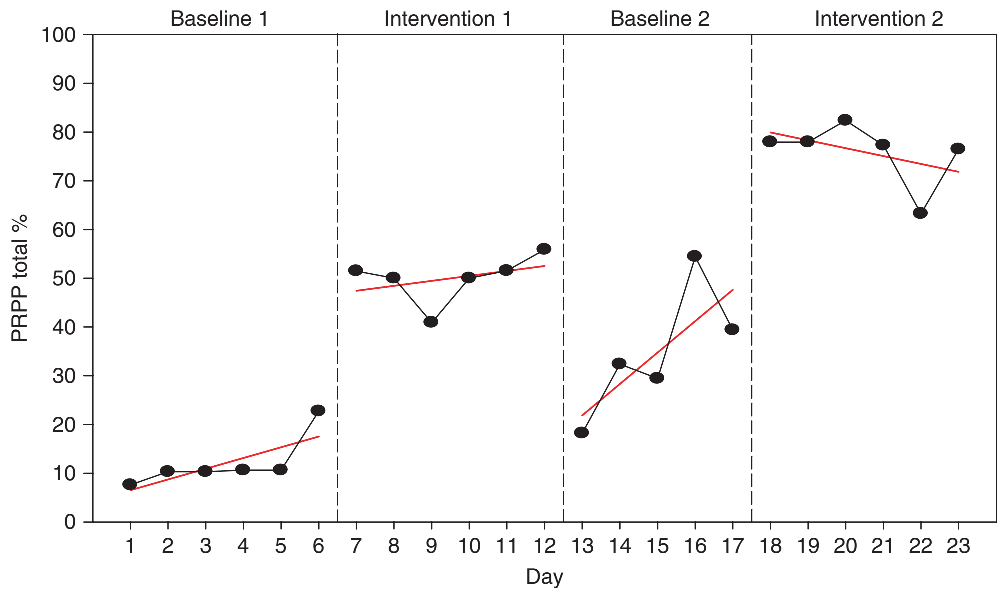

Figure 9. Subject 8—daily PRPP total % scores across each study phase.

This strategy focused approach appeared to be more effective than current occupational therapy instructional methods for improving information processing capacity within occupational tasks. Measures of treatment effectiveness suggest a large to very-large effect; with the PRPP Intervention explaining 68–92% of variance in task-based information processing capacity demonstrated by individual subjects.

Few published studies have attempted to evaluate occupational therapy intervention during the early stages of acute brain injury rehabilitation. In this study, subjects were specifically recruited whilst they remained in PTA and were functioning at Rancho Level IV or V. Three subjects emerged from PTA during the course of the study (Subjects 2, 3 and 4). All three demonstrated improved information processing strategy use during functional tasks both prior to and following emergence from PTA. After PTA emergence, Subjects 2 and 3 maintained quite high levels of performance with minimal variation, suggestive of a plateau reached coinciding with PTA emergence. In contrast, Subject 4 continued to demonstrate increases and decreases in PRPP scores with the introduction and withdrawal of the experimental intervention, even after PTA emergence. This may suggest that Subject 4's performance was more closely related to the effects of PRPP Intervention than PTA status.

Four subjects remained in PTA for the entire duration of the study (Subjects 1, 5, 6 and 7). Subject 5, who made least gains in this study, remained in PTA even though formal assessment was not conducted. All subjects demonstrated some improvement in ability to use information processing strategies during occupational performance, particularly during the PRPP intervention phases of the study. Presence of PTA *per se* did not appear to limit these subjects' ability to acquire information processing strategies and to implement these in daily occupational tasks targeted by the PRPP intervention. These findings further support the commencement of active therapy prior to the emergence from PTA and add to the growing body of evidence that supports learning during PTA when therapy is targeted towards functional skill development [5, 33–35].

A characteristic feature of PTA in many cases is agitated behaviour. Clinicians report feeling challenged when working with agitated patients and feel these behaviours interfere with progress in therapy [36, 37], limiting potential gains during the critical early stages of recovery [38]. Subjects in this study demonstrated agitation across a spectrum from low-to-very high levels, in some cases for a short period of the study and in some cases for the entire duration of the study. The highest levels of agitation were evident in the most severely injured subjects (5 and 6), a finding supported by literature [38]. In particular, Subject 5 did not improve to the same level that other subjects did, in fact the overall effect of time and intervention was not statistically significant. An inherent baseline level of cognitive processing may be required to benefit from either of the intervention approaches adopted in this study. As found in a previous study of adults with severe cognitive deficits [39] strategy training or training of compensatory techniques places heavy demands on a person's already limited cognitive abilities, which may reduce the effectiveness with severely impaired subjects. In spite of this, a promising trend towards improvement was seen with Subject 5 at the end of both PRPP Intervention phases. This highlights the potential for improvement and suggests that the effect of intervention may be gradual, requiring several days to consolidate the processing strategies that form the basis of the PRPP approach. In these cases, future research should consider extending the intervention period to better measure the effect of intervention.

The reversal design enabled repeated baseline measurements of the effect of current occupational therapy intervention and the contribution of natural recovery and therapeutic milieu. In all cases, processing strategy use during occupational tasks declined at the start of Baseline 2 (when the usual intervention approach was reintroduced), though it did not usually return to the level of Baseline 1. This effect may be accounted for in at least three ways. First, the process of natural recovery would predispose an individual to improved performance over time, even in the absence of therapy; therefore a complete return to Baseline 1 level of performance was not expected. Secondly, the Baseline phases represented current therapy, that is they *did not* represent an *absence* of therapy. Performance during both Baseline phases was expected to improve in response to current occupational therapy intervention. In general, Baseline 2 performance was characterized by an immediate drop in level at the time of withdrawing the PRPP Intervention, followed by several days of stable or gradually improving performance. This research design required an *additional* improvement in performance to demonstrate the effect of the PRPP Intervention approach. The third factor stopping performance levels returning completely to Baseline 1 levels is the potential effect of learning. Subjects who effectively learned information processing strategies during the first PRPP intervention phase may have applied these same strategies during therapy sessions in the second baseline. While there are methods for 'forcing a reversal' these practices are not recommended and were not included in the design of this study [15].

A frequently cited limitation of single-system research is poor generalization to other subjects within the same population. Several design features were in place to address generalization. The study protocol, that was highly effective with Subject 1, was systematically replicated across subjects and settings to accumulate evidence for external validity and generalization of findings [17, 19]. First the study protocol was replicated with three similar subjects (2, 3 and 4) and then with two more severely injured subjects (5 and 6). As expected, similar treatment effects were observed in Subjects 2, 3 and 4; whilst slightly lesser treatment effects were observed with Subjects 5 and 6. The study protocol was then replicated with subjects who had sustained different types of brain injuries, via different injury modalities, in different rehabilitation contexts. Subject 7 had an open head injury from a gunshot and Subject 8 had sustained a hypoxic brain injury. Both demonstrated very strong treatment effects in favour of the PRPP Intervention, suggesting the effect of intervention may generalize to open and non-traumatic brain injuries. Subject 7 was recruited into the study whilst on an acute-surgical ward. He completed part of the study protocol in this acute setting and part in the BIRU. Subject 8 remained in an acute setting throughout the entire study period. The large treatment effects observed in these subjects suggests the PRPP Intervention may also generalize to an acute ward setting and may result in even greater effects in comparison to usual treatment than in a specialized BIRU setting. Other factors such as subject age, time to rehabilitation admission and time to commence intervention may contribute to a greater or lesser treatment effect from the PRPP Intervention approach, though these factors could not be clearly evaluated in such a small sample.

Calculation of effect size in single-system designs is rarely published, with researchers preferring to rely upon visual analysis. Concerns regarding autocorrelation of data from single-system designs increasing the likelihood of Type I errors appears to deter researchers from utilizing statistical methods of analysis [40]. Data were checked and only a slight degree of positive autocorrelation existed between data within individual subjects' study phases; this degree of autocorrelation was not sufficient to produce serial dependency when assessed using procedures outlined by Ottenbacher [17]. Several different measures of effect size were calculated based upon published recommendations for single-subject and repeated measures designs [29, 40, 41]. All lead to the same conclusions regarding effectiveness of treatment. Partial eta squared was finally selected as the preferred effect size measure in this study, where differences between phases were initially measured using ANOVA on data that were not serially dependent.

The limitations of this study are inevitably those inherent in a single-system experimental design. Procedures to minimize threats to internal and external validity were included in the study design. Intra-rater and inter-rater reliability was established using retrospective video-analytical methods. Agreement achieved between the independent observer and the research therapist suggested that observer bias was minimal during this study, based upon the available video data representing one-quarter of all therapy sessions. Replicating the protocol across subjects and settings strengthened external validity.

Conclusion

This study evaluated the effectiveness of the PRPP System of dynamic assessment and intervention in comparison to current occupational therapy approaches with brain injured adults. Both approaches were shown to be effective, with the PRPP Intervention being significantly more effective than current intervention approaches. Adults in early stages of brain injury rehabilitation effectively learned and applied information processing strategies to improve task performance, in the presence of agitation and post-traumatic amnesia.

Using both the assessment and intervention components of the PRPP System enabled intervention to be directed by assessment findings specific to the person, task and environment. Previous studies have highlighted the clinical utility of the assessment component of the PRPP System [26, 27]. This case series presents the first published findings supporting the intervention component of the PRPP System. Future studies using the PRPP System of Assessment and Intervention are required to build on these initial findings, through examination of treatment effect across a broader range of patients at various stages of TBI recovery, in a variety of settings (for example post-acute rehabilitation) and with a larger group of therapists.

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