# Are Sleep Difficulties Associated with Cognitive Functioning Following Acquired Brain Injury in an In-Patient Neuro-rehabilitation Population?

## A Preliminary Study

## and

## Clinical Research Portfolio

Volume I

(Volume II bound separately)

**Allan Stuart Thomson**

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***Doctorate in Clinical Psychology (DClinPsy)***

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# CHAPTER 1: SYSTEMATIC REVIEW

## *Recent Advances (2009-2013) in Rehabilitation of Memory Deficits after Traumatic Brain Injuries or Stroke*

Allan Stuart Thomson*

***Submitted in partial fulfilment of the requirements for the degree of***

***Doctorate in Clinical Psychology (DClinPsy)***

Address for correspondence:

Allan Stuart Thomson

Academic Unit of Mental Health and Wellbeing

University of Glasgow

Gartnavel Royal Hospital

1055 Great Western Road

Glasgow, G12 0XH

Email: allan.thomson1@nhs.net

*Corresponding author.

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**KEYWORDS:** TBI, Stroke, Memory, Rehabilitation, PEDro-P

**Abstract**

**Background:** Cicerone et al. (2000, 2005 and 2011) conducted three systematic reviews examining the evidence base for cognitive rehabilitation in Traumatic Brain Injury (TBI) and stroke, and most recently reviewed articles published between 2002 and 2008. They recognise that a weakness of their reviews is that they only consider the level of evidence based on the type of design and do not evaluate the methodological quality of studies. **Primary objective:** To systematically review the effectiveness of memory rehabilitation strategies for adults with TBI or stroke, in papers published between January 2009 and May 2013 and to explore the utility of the PED-ro-P, an online methodological quality rating for neuropsychology research.

**Method:** An electronic database search was conducted identifying 711 articles. Cicerone et al.'s. Inclusion/ exclusion criteria were applied and 11 new papers were included in the review. Appropriate articles were reviewed using the levels of evidence criteria used by Cicerone et al. and the PEDro-P.

**Results:** Internal and external compensatory strategies approaches have some benefit in memory rehabilitation post TBI and stroke however, it is unclear if therapeutic gains are maintained at follow up. There is some preliminary evidence supporting restitution approaches however, the studies small sample sizes make it unclear if the results are generalisable. Higher PED-ro-P scores, indicating better study design, were associated with better study class defined by the criteria adopted by the Cicerone et al. review series. However, the PED-ro-P identified variability in the methodological quality between studies classed at different levels using Cicerone et al.'s criteria.

**Conclusions:** Internal and external compensatory strategies improve memory after TBI and stroke, consistent with the Cicerone et al. review series. However, it was not clear if these approaches have long term benefits because studies did not assess treatment effects at follow-up. There was not enough evidence to make recommendations on interventions suitable for different levels of memory impairments. The PED-ro-P provides precision to the criteria used by Cicerone et al. by robustly critiquing methodological quality. Methodological variability was found in studies highly rated using Cicerone et al.'s criteria and there appeared to be overlap in the methodological quality of lower rated studies, suggesting different recommendations may have been made by Cicerone et al. if they adopted the PED-ro-P. Future research should focus on methodological quality, injury severity and degree of memory impairment. Future reviews would benefit from using a methodological quality rating tool such as the PED-ro-P.

## Introduction

Memory is the process by which information is encoded, stored and retrieved. Memory impairments arise when encoding and storage processes are impaired by disease or accident; learning new information or recall will vary from patchy to none at all (Kapur, 1988). The extent of these deficits is largely determined by lesion location (Lezak et al., 2012). Memory impairments are frequently observed in Traumatic Brain Injury (TBI) and stroke patients.

*"Cognitive rehabilitation is defined as a systematic, functionally oriented service of therapeutic activities that is based on assessment and understanding of the patient's brain-behavioural deficits"* (Cicerone et al., 2000, p. 1596). It can be directed specifically towards memory deficits acquired after TBI and stroke. Currently memory rehabilitation can be considered as consisting of two approaches, compensatory and restitution. Compensatory approaches involve introducing a strategy or an aid that will appease cognitive deficits and do not aim to restore the area of deficit. Restitution approaches aim to improve deficits through training by forcing the areas of the brain damaged to work again (Held et al., 1999).

Cicerone et al. (2000, 2005 & 2011) conducted three systematic reviews examining the evidence base for cognitive rehabilitation in TBI and stroke. Each review explored intervention literature for specific domain based cognitive deficits (e.g. attention, memory, executive functioning) and multi-faceted approaches aiming to alleviate deficits across a number of cognitive domains. The most recent review examined papers published between 2002 through 2008 (Cicerone et al., 2011). The Cicerone et al. series are regarded as providing the most exhaustive search of the literature to date (Rohling et al., 2009). Only 2 articles included in other reviews were not included in the series (Cicerone et al., 2011). They make recommendations on the best approach to memory rehabilitation, based on research evidence. The most recent review concluded that memory strategy training using both internal and external compensations for people with mild memory difficulties following

TBI has the strongest evidence. They also found moderate evidence for using external compensations for people with severe memory deficits and some evidence for the use of errorless learning techniques for learning specific skills and group based interventions for remediating memory deficits.

The Scottish Intercollegiate Guideline Network (SIGN 130, 2013) recently published a guideline on *Brain Injury Rehabilitation in Adults* concluding that evidence from memory rehabilitation supports (i) the use of both internal and external compensatory strategies following mild-moderate memory impairment and external compensation for severe memory deficits and (ii) the use of errorless learning for moderate-severe memory impairments (SIGN 130, 2013). SIGN 130 supports the use of compensatory strategies but does not view restitution approaches as being effective consistent with the Cicerone et al. series.

Rohling et al. (2009) carried out a robust meta-analysis of Cicerone et al.'s 2000 and 2005 reviews and concluded memory rehabilitation research is "mixed and weak" (p.33), contrary to Cicerone et al.'s view that there is strong evidence for memory rehabilitation approaches. Cicerone et al. (2011) disagree with Rohling et al., arguing that differing conclusions are attributable to different methodologies. Cicerone et al. (2011) argue that Rohling et al. neglected to distinguish between active and "sham" (p.520) interventions, those comparing two active intervention conditions and that by excluding non-controlled and single case studies, they risked losing relevant information. Rees et al. (2007) completed a systematic review with specific recommendations for memory rehabilitation, supporting the use of internal and external memory strategies, and memory training programmes, consistent with Cicerone et al.'s conclusions.

Cicerone et al. (2009) acknowledge that there are some discrepancies in conclusions made when evaluating the same literature (Rohling et al. 2009). This may be due to reviews not

incorporating criteria examining the methodological quality beyond the level of evidence. Cicerone et al. (2011) recognise not evaluating the methodological quality of studies and only considering the level of evidence based on the type of design, is a weakness of their reviews. Cicerone et al. (2009) created a methodological quality rating scale to re-evaluate RCTs and non-randomised observational studies included in their 2000, 2005 and 2011 (described as in-press) publications, and concluded that methodological quality rating criteria can clearly aid in the evaluation of cognitive rehabilitation.

The present review adopts the criteria used by the Cicerone et al. review series to update their most recent review by evaluating studies on memory rehabilitation published between January 2009 and May 2013 - this is the period succeeding the review period (2002-2008) of Cicerone et al. (2011). The PED-ro-P methodological quality rating scale is also used to respond to the weaknesses identified in the Cicerone et al. series. The PED-ro-P was selected in favour of the scale developed by Cicerone et al. (2009) as the PEDro-P is the criteria adopted by the Psychological Database for Brain Impairment Treatment Efficacy (psycBITE), an online neuropsychology resource. PsycBITE provides clinicians with easy access to rehabilitation literature that has been evaluated using PED-ro-P. Systematic reviews quickly lose their relevance (Tate et al., 2004), therefore PED-ro-P scores within this review can be easily compared with new literature.

## Aims

To systematically review the effectiveness of memory rehabilitation strategies for adults with a Traumatic Brain Injury or stroke in papers published between January 2009 and May 2013.

## Research Questions

Do strategies[1] effectively improve memory deficits following Traumatic Brain Injury and stroke?

Is the PED-ro-P a useful tool in evaluating the methodological quality of memory rehabilitation studies when compared to the method employed by Cicerone et al. (2000, 2005, 2011)?

## Method

*Search strategy*

The following electronic databases were searched for articles published between January 2009 and May 2013: Medline, Psychinfo, PsycArticles, CINAHL, Psychology & Behavioural Sciences Collection and Health Source Nursing/ Academic Edition.

The following search terms were developed from the search terms described in the Cicerone et al. (2000, 2005, 2011) reviews:

1. Head injur* or brain injur* or strok* or tbi

AND

2. Memor*

[1] A strategy was considered to be a cognitive rehabilitation intervention that was defined as a "systematic, functionally orientated service of therapeutic activities" (Cicerone et al., 2000 p.1596) that were specifically directed towards memory problems. Compensatory (encompassing memory aids) and restitution approaches are the approaches that are considered to comprise memory rehabilitation.

AND

3. Rehab* or train* or treat* or remediati* or interven*

*Inclusion criteria*

Inclusion and Exclusion criteria were developed based on the criteria used by Cicerone et al. (2000, 2005, 2011). An exact replication of the criteria was not possible due to this review only focussing on interventions aiming to alleviate memory deficits whereas Cicerone et al. focused on studies intervening across cognitive domains.

- Published in a peer reviewed journal
- Published January 2009-May 2013
- Written in English
- Intervention studies addressing memory impairments following TBI and/ or stroke. (An intervention study was when cognitive rehabilitation was delivered specifically directed towards memory impairments. Compensatory (internal and external) and restitution were the approaches that were considered to constitute a memory intervention.)
- Studies that included participants who had both a TBI and stroke would be considered due to the similarities associated with both conditions, specifically, the fact that both are non-degenerative conditions.
- Mixed aetiology studies that included a diagnosis of 'other brain injury' were included when it was possible to distinguish the results of participants who had a TBI or stroke. Otherwise these studies were considered as not having participants with a primary diagnosis of TBI or stroke. Inclusion of mixed aetiology studies allowed the effectiveness of the interventions for individuals who had sustained a TBI or stroke to be considered.
- Participants aged 18-65

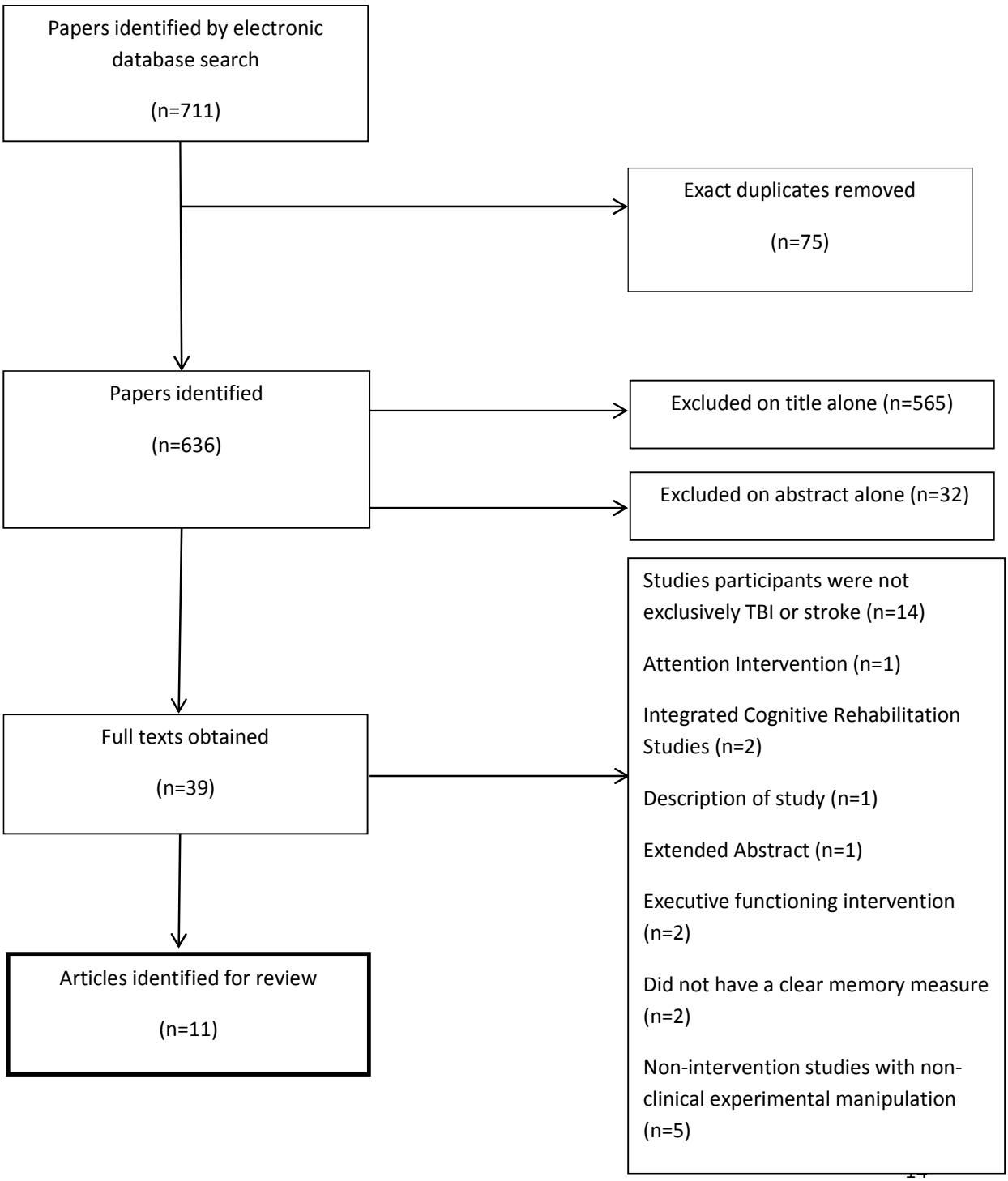
*Exclusion criteria*

- Non-intervention articles, including non-clinical experimental manipulation
- Studies examining surgical or pharmacological interventions
- Non-peer reviewed articles
- Theoretical or descriptions of interventions
- Qualitative research
- Review papers
- Studies that do not include a clear measure of memory
- Book chapters
- Conference abstracts
- Articles that did not include participants with a primary diagnosis of TBI or stroke
- Single case reports without empirical data
- Articles without adequate description of interventions
- Integrative cognitive rehabilitation studies and working memory studies. (The Cicerone et al. review series considered these studies independent of memory.)

*Manual Search*

All reference lists of journal articles selected for inclusion from the electronic search were reviewed to identify further articles. No articles were sourced using this method.

**Figure 1. Flow diagram illustrating search process**



**Quality Rating Criteria**

Studies were initially assessed using the criteria described by Cicerone et al. (2000) to determine the level of evidence (See appendix 1.1). These were adapted from the American Association of Neurologic Surgeons (1995) and Woolf (1992). Articles were then assessed using PEDro-P, an 11 item scale that produces a quality rating score out of 10 (one item is not included in the quality score) and identifies potential sources of bias. Maher et al. (2003) tested the reliability of the total PEDro-P score and found that it is "fair to good" (p.718). This is comparable to other commonly used rating scales. Single n designs were not assessed using PED-ro-P due to the tool not being suitable to evaluate this type of study design. Single n designs were however, assessed using the level of evidence criteria described by Cicerone et al.

Before using the PEDro-P the author completed an online training package on the tool's administration (www.psychbite.com). Papers were rated by the author and an independent reviewer, using Cicerone et al.'s level of evidence and the PEDro-P. Overall agreement was 98.8%. Any discrepancies were resolved through discussion. Four of the 8 papers reviewed with PED-ro-P were reviewed by at least two experts on the psycBITE website. A good inter-rater reliability of 95% was found with this review and psycBITE expert ratings. A breakdown of PEDro-P scores for each article can be found in appendix 1.2

**Table 1. Descriptions and Quality Ratings of Included Studies**

| Study | Study Class | PEDro Quality Rating | Description of intervention | Sample Characteristics | Memory Outcome Measures | Conclusions | Effect sizes (Cohens d) |
|---|---|---|---|---|---|---|---|
| *Internal Compensatory Approaches* | | | | | | | |
| Aben et al. (2013) | Class I | 9/10 | Randomised control trial (RCT). Participants completed Memory self-efficacy (MSE) training programme (intervention) or attend a peer support group (control). MSE training consisted of challenging negative beliefs about memory functioning, training in memory strategies and education in the influence of perceptual bias.<br><br>The training programme consisted of 9 twice weekly group sessions of 1 hour, the control group followed the same schedule.<br><br>Outcome measures were completed within 3 weeks prior to intervention and within 10 days after completion. | **Intervention**<br>n=77<br>Mean Age=58.3<br>Mean time post stroke= 52.41 months<br><br>**Control**<br>n=76<br>Mean Age= 57.86<br>Mean time post stroke= 55.34 months<br><br>All participants had one stroke at least 18 months before the study and self-report memory complaints. | MIA<br>AVLT<br>RBMT | MSE significantly improved in intervention participants compared to control.<br><br>There was not a significant difference between performance on AVLT and RBMT between groups.<br><br>Younger patients and those with a better verbal memory were predictors for improvements in MSE. | Adequate information not provided to calculate effect size. |
| Shum et al. (2011) | Class I | 7/10 | 2x2 RCT. Participants were assigned to 1 of 4 groups; | **Self awareness training plus** | CAMPROMPT | Prospective memory test score and | Adequate information |

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| | | | self-awareness training (S-A) plus compensatory prospective memory training, S-A plus active control, active control plus compensatory prospective memory training and active control only.<br><br>Self-awareness training aimed to increase awareness of deficits. Sessions involves education and prospective memory tasks.<br><br>Active control for self-awareness training involved discussing experiences.<br><br>Compensatory PM training involved strategy training to compensate for prospective memory problems.<br><br>Active control for compensatory involved remedial training of prospective memory deficits. | **<u>compensatory training</u>**<br>n=12<br>Median Age=23.5<br>Median time since injury= 348 days<br>Median length of PTA= 50.5 days<br>Median Initial GCS= 4<br>Median WASI IQ= 103<br><br>**<u>Active Control plus compensatory</u>**<br>n=11<br>Median Age=33<br>Median time since injury= 209 days<br>Median length of PTA=35 days<br>Median initial GCS= 7<br>Median WASI IQ= 106<br><br>**<u>Self awareness training plus active control</u>**<br>n=11<br>Median Age=23<br>Median time since injury= 368 days<br>Median length of | | strategy use were larger in interventions with compensatory memory training components compared to groups without. | not provided to calculate effect size. |

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| | | | | PTA=41 days<br>Median initial GCS= 6<br>Median WASI IQ= 103<br><br>**Active Control**<br>n=11<br>Median Age=24<br>Median time since injury= 194 days<br>Median length of PTA=29.5 days<br>Median initial GCS= 8<br>Median WASI IQ= 109<br><br>All participants had a moderate to severe TBI defined by GCS<13, PTA 24> or neuropathology identified on a CT or MRI scan. | | | |
| Potvin et al. (2011) | Class II | 4/10 | Repeated measures design. Prospective memory rehabilitation programme consisted of 10 weekly individual sessions lasting approximately 90 mins. Intervention involved learning of visual imagery | **Intervention**<br><br>n = 10<br>Mean Age= 35<br>Mean Education= 11 years<br>Mean PTA= 30.60 days | TEMP | Prospective memory rehabilitation participants performance significantly improved on the TEMP compared to the control group. | **TEMP**<br>Within subjects pre/post<br><br>Intervention d= -2.31 |

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| | | | techniques. Control participants received education.<br><br>Outcome measures were completed on the 1st and final day of the programme. | **Control**<br><br>n=20<br>Mean Age= 30.90<br>Mean Education=11.70 years<br>Mean PTA= 29.20 days<br><br>All participants had sustained a TBI of varying severity | | | Control<br>d= -0.46 |
| O'neil-pirozzi et al. (2010) | Class II | 3/10 | Non-randomised pre-/post group comparison design. Experimental intervention I-MEMS consisted of 12, 90 min group sessions held twice weekly for 6 weeks. Intervention focussed on the use of internal memory strategies.<br><br>Outcome measure were completed at week 1, week 7 and week 11 | **Intervention**<br>n= 54<br>Mean Age =47.3<br>Mean Education= 14.5 years<br>Mean time post injury=11.8 years<br><br>**Control group**<br>n= 40<br>Mean Age= 47.0<br>Mean education =15 years<br>Mean time post injury = 13.4 years<br>All participants have sustained a TBI at least 12 months before participation. | HVLT-R<br>RBMT-II | I-MEMS significantly improved performance on the HVLT-R and RBMT II.<br><br>Severe TBI was associated with less improvement than mild and moderate injuries | **HVLT-R**<br>*Post-test 1*<br>d= 0.18<br>*Post-test 2*<br>d= 0.35<br><br>**RBMT-II**<br>*Post-test 1*<br>d= 0.69<br>*Post-test 2*<br>d= 0.72 |

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| Stringer (2011) | Class III | 3/10 | Unblinded, pre/post-treatment comparison. All participants completed the Ecologically-oriented neurorehabilitation of memory programme (EON-Mem). EON-Mem is a treatment manual approach where participants are taught how to apply the write- organise- picture-rehearse (WOPR) approach in a number of contexts. Goals were set at the start of intervention and homework was set to consolidate skills learned.<br><br>To complete the programme participants had to complete 20, 1hour weekly sessions. Not all participants completed the whole programme but an intention to treat design was followed and all participants completed the post treatment follow up. | **Stroke**<br>n= 12<br>Mean Age= 52.3<br>Mean months since onset= 7.5<br>Mean years in education=14.7<br>Mean memory severity (z-score)=-2.4<br><br>**TBI**<br>n= 15<br>Mean Age= 35.7<br>Mean months since onset= 19.6<br>Mean years in education=14.5<br>Mean memory severity (z-score)=-2.2 | EMS | Stroke and TBI participants showed statistically significant improvement in memory performance<br><br>Participants with both mild-moderate and severe injuries had statistically improvement on EMS tasks. This should be interpreted with caution, in terms of this review, as it included patients with other neurological conditions along with stroke and TBI in this analysis. | Adequate information not provided to calculated effect sizes. Some effect sizes reported however, they did not appear to be cohens d. |
| *Memory Aids (External Compensations)* | | | | | | | |
| Bergquist et al. (2009) | Class 1A | 5/10 | Within subjects cross-over design.<br>Participants received instant | **Intervention 1st**<br>n=6<br>Mean Age= 42 | NFI<br>CIQ<br>CTQ | No significant differences between intervention and | Adequate information not |

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| | | | messaging training and completed either calendar intervention or the diary control condition first. The intervention involved participants receiving instant messaging therapy sessions comprising acquisition of skills to use the calendar, application of the skills through utilisation/ role play and adaptation, applying it to real life. In the control condition participants logged day to day events in a diary and they received on line therapy sessions where reviewing the events logged. | Education= 2 some college, 4 college graduate.<br>**Control 1st**<br>n=8<br>Mean Age= 48<br>Education= 3 High School or less, 5 College graduate.<br><br>All participants had moderate to severe TBI defined by GCS<13, PTA24> hours, or evidence of brain related abnormalities on neuroimaging. | RBANS | control conditions for memory functioning.<br><br>Significant improvements in the use of compensatory strategies and family reports of improved memory were found. | provided to calculate effect size. |
| Dowds et al. (2011) | Class 1A | 4/10 | Multiple cross over design, where completion rates of memory tasks were recorded under 4 conditions. (i) Baseline relying on participant's normal strategies, (ii) using paper memory aid, (iii/iv) conditions using 2 different palm top computers. 8 week study where conditions were randomly changed weekly. | n= 36<br>Mean Age =42.1<br>Females= 19<br>Males=17<br>All participants had a history of TBI and self-report memory complaints. | Rate of timely completion of assigned call in tasks. | Participants timely task completion was significantly higher when using either of the palm top computers compared to baseline and the paper memory aid.<br><br>Task completion rates for the paper organizer were comparable to the baseline condition. | Adequate information not provided to calculate effect size. |

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| | | | | | | One palm top computer produced significantly better scores than the other device. | |
| Boman et al. (2010) | Class III | N/A | Single subject design with multiple baseline AB design. A phase was the baseline condition where no reminders were given. B was the intervention condition where an electronic memory aid provided spoken reminders. | n=5<br>Age range= 33-58<br>Range years since onset= 1-8<br><br>All participants had a stroke or TBI at least 1 year before the study commenced. Participants had memory impairment verified by the RBMT and some insight into their difficulties. | Participants identified activities that they had difficulty completing. Computer software measured completion of these activities.<br>COPM<br>RBMT | There was no significant difference between baseline and intervention on the number of tasks completed. Removing one participant who refused to use the aid the results neared significance.<br><br>COPM self-report performance, satisfaction with performance and quality of life improved.<br><br>There was no change in RBMT performance between participants at pre, post and follow up.<br><br>Clinically the electronic memory aid helped improve completion of most of | N/A |

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| | | | | | | the activities of 4 participants. | |
| *Restitution Approaches* | | | | | | | |
| Chen et al. (2012) | Class I | 6/10 | Randomised control design. Treatment participants received an approximately 90 min global process training session where they learned a global to local encoding strategy. Control participation received approximately 90 min of rote repetition training where no strategies were taught.<br><br>Participant's complex figures retrieval was evaluated during training, next day, 2 weeks and at 4 week follow up. | **Intervention**<br>n=6<br>Mean age= 73.8<br>Mean education= 14.8 years<br>Mean number of days since stroke= 48<br><br>**Control**<br>n=5<br>Mean age= 74<br>Mean education= 12.6 years<br>Mean number of days since stroke= 35 | Complex figure test performance. | Complex figure completion was significantly better directly after training and at 24 hours post training for individuals who completed global process training compared to those who completed rote repetition training.<br><br>Significant differences were not found between groups on complex figure test performance at 2 and 4 weeks post training. | **Between group effects complex figure recall**<br><br>*Next day*<br>d= 0.44<br><br>*2 weeks*<br>d= 0.38<br><br>*4 weeks*<br>d= 0.35 |
| Jang et al. (2012) | Class III | N/A | Single n design. 2 memory training sessions were conducted daily, 5 days per week for 3 months. Participant received a 6 stage training programme on a table PC, each stage consisting of visual and auditory sessions. The tablet sent results via the internet to health staff who used this to give the participant feedback. | n=1<br>Age= 37<br>Sex= Male<br>Cause of injury= traffic accident | MAS | Before training MAS scores were similar over a period of a month. After starting training MAS scores started to show improvement. | N/A |

| | | | | | | | |
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| Caglio et al. (2012) | Class III | N/A | Single n design. Participant completed navigational memory training on a computer. The training consisted of 90 min sessions, 3 times per week for 5 weeks.<br>Outcome measures were delivered pre, post, 2 month follow up and 1 year follow up. | n=1<br>Age= 24<br>Glasgow coma scale= 5<br>TBI of moderate severity sustained in a traffic accident.<br>Training started 1 year after the injury. | Corsi Block-Tapping Test<br>Corsi's supraspan test<br>Backward digit span<br>RAVLT<br>RBMT | Improvements pre and post training were observed better performance in tests assessing visuo-spatial learning. | N/A |

Key

HVLT-R= Hopkins Verbal Learning Test-Revised
RBMT-II= Rivermead Behavioural Memory Test II
TEMP= TestE ´ cologique de Me´moire Prospective
MIA= Meta-memory in-Adulthood questionnaire
AVLT= Auditory verbal learning test
RBMT= Rivermead behavioural memory test
COPM= Canadian Occupational Performance Measure
MAS= Memory Assessment Scale
RAVLT- Rey Auditory Verbal Learning Test
EMS= Everyday memory stimulations
NFI= Neurobehavioural functioning inventory
CIQ= Community Integration Questionnaire
CTQ= Compensation techniques questionnaire
GCS= Glasgow Coma Scale
PTA= Post Traumatic Amnesia

## Results

### *Internal Compensatory Approaches*

#### Class I

*Aben et al. (2013) 9/10*

Participants were recruited from two rehabilitation centres. Both intervention and control groups were comparable in terms of intensity and frequency of contact. The intervention group however, received homework. Delivering a control homework condition would have strengthened the design as a homework condition regardless of content may have had therapeutic benefits. For example, it could have motivated participants to engage in purposeful activity increasing mood and perceived memory self-efficacy. A suitable control homework task could have involved participants completing questions relating to the general education about stroke that was discussed with peers when engaging in the control condition. Both groups were moderated by a trained psychologist. Allocation to groups was concealed by using an independent investigator. There were no differences between important prognostic indicators for both groups. Participants were not aware if they were receiving the intervention or control, minimising the risk of performance biases. It was not possible to blind therapists due to the content of the conditions but researchers who assessed outcome were blind to group allocation. Eighty-five percent of participants who were allocated to the experimental group and 90% of those allocated to the control group completed the study. The data was analysed using intention to treat for all participants who failed to complete the study. Between groups analysis was completed using independent t-tests although it was unclear if the data had been analysed to check it met the assumptions for parametric analysis. A regression model suggested that young patients with better memory capacity benefited most from the training programme. Analysing participant characteristics such as memory capacity was commendable, giving insight into factors that affect treatment efficacy. The study failed to investigate if treatment benefits were maintained at follow up.

*Shum et al. (2011) 7/10*

Community dwelling adults who had previously received care or were recently admitted as outpatients from a hospital brain injury rehabilitation unit were recruited to take part. Participants were allocated to groups using restricted randomisation with blocking. All interventions involved 8 weekly sessions of 1.5 hour duration, ensuring equity between groups. The interventions were delivered by a "trained" (p.43) researcher who was a qualified occupational therapist and followed standardised procedures. The therapist's level of training was unclear and if they deviated from the standardised procedures. Allocation was concealed using numbered cards selected by a researcher blind to assessment results. Statistical comparisons between the 4 groups for gender, age, time since injury, length of PTA, initial GCS and WASI IQ were non-significant. The paper does not acknowledge whether participants were blind to the intervention received. Therapists were aware of the interventions they delivered. Retention rates were 83.3%, 90%, 81.8% and 63.3% for each group. Missing data was analysed as 'intention to treat'. Appropriate statistical comparisons between groups were completed. Maintenance at follow up was not investigated.

**Class II**

*Potvin et al. (2011) 4/10*

Participants were patients who had been treated for TBI, in a Canadian hospital, in the last 10 years. Monetary reward was offered to all participants, potentially increasing motivation to engage in both conditions. Assignment to groups was based on age and education to match the groups. T-tests indicated the groups did not differ on age, education, premorbid IQ, PTA, coma and evolution.. The control group had a larger n than the intervention group and had different intensity and frequency of sessions. Subjects, therapists and assessors were not blinded to group allocation. Outcome measures were obtained for 100% of participants calculated from degrees of freedom values denominator values of the ANOVA. ANCOVA

analysis was completed to control for between group differences on TEMP scores. Maintenance at follow up was not investigated.

*O'Neil-Pirozzi et al. (2010) 3/10*

Participants were volunteers who had sustained a TBI of any severity and had engaged with hospitals, support groups or study affiliated doctors in Massachusetts. Increased motivation is a pertinent factor for volunteer participants. The intervention group were already engaging in a study assessing the ability of functional magnetic resonance imaging (fMRI) to predict the outcome of a memory rehabilitation programme and controls were individuals who could not participate in the intervention group or were explicitly recruited for the control group. Control group participants who could not participate in the fMRI study may have had decreased performance on outcome measures as they were aware that they could have been receiving the intervention, if it was not for other commitments. Prognostic indicators were described for both groups but no statistical comparisons were completed suggesting there may have been inequities between groups. There were no between group differences on RBMT scores pre intervention but there was a significant between groups difference between HVLT-R scores at baseline. Differences in HVLT-R scores were controlled for by using statistical adjustment in the regression analysis. Participants were not blinded to group allocation and no meetings were held with control group participants except to collect outcome data, suggesting factors other than the content of the session, could have influenced treatment effects. Therapists and assessors were not blinded to group allocations. However, different assessors conducting pre and post group evaluations. Ninety-eight percent of participants completed the intervention and 97.5% completed the control group. Intention to treat analysis was not used. Independent t-tests were used to make between group comparisons although, it was unclear if the data met assumptions for parametric analysis. One month post intervention follow up was completed where treatment effects were maintained.

**Class III**

*Stringer (2011) 3/10*

The sample comprised outpatients from an experimental neuropsychology clinic who volunteered to be referred for cognitive rehabilitation. All participants had memory difficulties following onset of a neurological problem. Participants were allocated to one of three groups dependent on diagnosis – TBI, stroke or other neurological condition. Only comparisons between stroke and TBI will be considered in this review. All participants were grouped depending on severity of memory impairment, determined by neuropsychological testing performance. All participants received an ecologically orientated, strategy based intervention that was clearly described in the methods section of the paper. ANOVA analysis revealed all participants were similar in years of education, time since onset, full scale IQ and severity of memory impairment. Participants did differ significantly in age, with stroke patients being significantly older which was expected. No blinding of participants, therapists or assessors occurred in this study. It was not clear how many participants completed the study but an intention to treat analysis was completed to account for drop outs. It should be noted that patients with mild-to-moderate memory impairment received significantly fewer treatment sessions. It was unclear if the data met the assumptions for ANOVA and ANCOVA analysis. Maintenance at follow up was not investigated.

***Memory Aids (External Compensations)***

**Class 1A**

*Bergquist et al. (2009) 5/10*

Volunteers were recruited through flyers in the local community. Participants were randomly allocated to the intervention and control internet based conditions using a random number table. Control group participants spent as much time on the internet interacting as the intervention group that attempted to make any treatment effects attributable to the content of

cognitive rehabilitation. The researchers acknowledge that in fact there may have been too many similarities between groups. Allocation is assumed to be concealed as participants completed baseline measures before being allocated to groups. It was reported that there were no significant between group differences for participant characteristics, although details of analyses completed are not reported. Participants, therapists and assessors are assumed not to be blinded to interventions as this is not discussed in the paper. Seventy-five percent of participants who were allocated to the intervention first completed the study and 80% of participants who were allocated to the control first completed the study. Maintenance at follow up was not investigated.

*Dowds et al. (2011) 4/10*

Participants were recruited from a number of rehabilitation centres in the Boston area and were referred by carers and professionals. Participants had good visual acuity and the ability to use the personal digital assistant devices. Participants completed personally set tasks using normal strategies for a week and then were randomly allocated to a paper based schedule book or to one of two personal digital assistant conditions. Outcome was measured by timely completion of one set task and three personalised activities. Personalised activities could have varied in difficulty between participants questioning the comparability of results however, use of personalised tasks increases ecological validity of interventions. Allocation to conditions was not concealed to the research team. The researchers did not complete statistical comparisons between important prognostic indicators. They also did not confirm if all participants were similar at baseline. Subjects, therapists and assessors were not blinded to group allocation. 94% of participants originally allocated to groups completed the study. The study does not report using intention to treat analysis. Appropriate statistical analysis was used. Sex or age did not appear to effect task completion rates. Maintenance at follow up was not investigated.

**Class III**

*Boman et al. (2010)*

Single subject design to examine the possibilities of a home based electronic memory aid. 5 participants were recruited who had either sustained a TBI or stroke. Participants identified activities to use the technology with and 4 participants improved in completing activities. Improvements in satisfaction with performance and quality of life were also observed. Maintenance at follow was not investigated.

***Restitution Approaches***

**Class I**

*Chen et al. (2012) 6/10*

Stroke participants with visuospatial memory impairments were recruited by referral from doctors and therapists in two acute inpatient rehabilitation hospitals. All participants had lesions in the right hemisphere and visuospatial memory deficits. Participants were right handed and had no visual impairments to ensure they had the ability to complete visual tasks. Randomisation into groups occurred. Intervention and control conditions were comparable in terms of the amount of verbal instruction and number of drawings produced. Both groups were comparable on gender, age, years of education, days post stroke, mood, spatial neglect and general cognition. Randomisation was completed by a laboratory associate completely independent of the study. Participants were unaware if they were allocated to the intervention or control condition, minimising the risk of performance biases. The therapists/assessors however, were not blind to treatment group. Some attempts to remove assessor bias were made by having two independent raters blind to training conditions score the complex figure drawings. Outcome measures were obtained for 83% of participants allocated to the intervention group and 80 % allocated to the control condition. Obtaining outcome measures for less than 85% of participants increases the risk of attrition bias. This study had relatively small numbers of participants allocated to each condition and

lost one participant in each group. Due to the small sample size, percentages of completion appear low with a small dropout rate. The paper did not discuss 'intention to treat' suggesting that there may be biases associated with non-random loss of participants. Treatment effects were found to be present at 24 hours post intervention but were not present at 2 and 4 weeks follow up.

**Class III**

*Caglio et al. (2012) n/a*

Single case study showing navigational training using a 3D virtual reality video game improved memory after training and at follow up, for a young male who sustained a TBI of moderate severity.

*Jang et al. (2012) n/a*

Single case study exploring a tablet computer memory rehabilitation programme that consisted of visual and auditory components. Improvements were observed in global, short term, visual and verbal memory after two training session for 5 days per week for weeks with an individual between 9 and 11 months after injury onset. Maintenance at follow up was not investigated.

## Discussion

### *Recent Advances*

*Internal Compensatory strategies*

Two class I, 2 class II and 1 class III study that focused on compensatory strategies were evaluated. All except one class I study (Aben et al., 2013) demonstrated that the interventions were beneficial. The interventions delivered in each study comprised different therapeutic techniques and taught different compensatory strategies. Aben et al. (2013) focused on training memory self-efficacy which did not improve memory performance but increased perceived memory self-efficacy in stroke patients. The authors predicted memory

performance may not improve- due to the time that had elapsed after the participants stroke. One class I study (Shum et al. 2011) and 1 class III study (Stringer., 2012) found individually delivered interventions improved memory performance in TBI and stroke and TBI patients respectably. Two class II studies (Potivin et al., 2011; O'Neil-pirozzi et al., 2010) found group interventions improved memory performance in TBI patients. Only O'Neil-pirozzi et al. confirmed memory performance improvements were sustained at one month follow up.

*Injury severity*

Past Cicerone et al. reviews concluded that patients with mild to moderate memory impairments benefit more than those with severe impairments from compensatory strategy training. Aben et al. and Stringer considered memory impairment with Aben et al., finding younger participants with better memory capacity benefitted from intervention and Stringer finding participants benefitted regardless of level of impairment. However, Stinger reported those with milder impairments received fewer sessions. Shum et al., Potvin et al. and O'Neil-pirozzi et al. did not report level of memory impairment. Shum et al. included participants who had sustained a moderate to severe injury and Potvin et al. and O'neil-pirozzi et al. included participants with varying injury severity. There appears to be growing evidence that individuals with TBI of varying severity benefit from compensatory training but the results should be interpreted with caution, as severity of TBI may not always be linked with severity of memory impairment. Consensus needs to be developed on the criteria used to determine injury severity and level of memory impairment.

*Memory Aids (External Compensations)*

Two class IA and 1 class III study were evaluated that focused on electronic memory aid intervention. One class IA study (Bergquist et al. 2009) found no differences in memory performance but increased use of compensatory strategies and family reports of memory improvement when participants engaged in internet based cognitive rehabilitation. Similarities between the control and intervention conditions may have resulted in any effects

being lost. One class IA (Dowds et al., 2011) study found memory improved using electronic memory aids and a class III study (Boman et al. 2010) found that aids produced clinically significant improvements. Dowds et al.'s findings should be interpreted with caution, as it was unclear if all participants were similar at baseline as they completed personalised tasks. The study also did not confirm statistically that all participants were similar on prognostic indicators. Arguably this is not as important for this study as it is a crossover design.

*Injury Severity*

Bergquist et al. recruited patients defined as having moderate to severe TBI defined by GCS, PTA or neuroimaging, Dowds et al. and Boman et al. did not account for injury severity. Cicerone et al. previously concluded that people with moderate to severe injuries benefit from external memory aids. This is not clear in this review as recent literature used did not find an effect (Bergquist et al.) or did not define injury severity (Dowds et al. and Boman et al.).

*Restitution Approaches*

One Class I and 2 class III studies focused on restitution approaches. Global process training appeared to successfully improve visuospatial memory deficits immediately after training and at 24 hour follow up in patients with right sided stroke and visuospatial memory deficits (Chen et al. 2012). Improvements were not observed at follow up. In a single n study, Jang et al. (2012) found that a computer memory rehabilitation programme, consisting of auditory and visual components, improved memory performance in a number of areas. Navigational training using a 3D virtual environment was also shown to improve memory after training in a single case study with a young male with a TBI of moderate severity (Caglio et al. 2012).

*Methodological Quality (Not including single n studies)*

The PEDro-P rating checklist identified that the methodological quality varied between studies reviewed. The quality rating scale facilitated a robust critique of the methodology of studies. Papers reporting inclusion criteria allow clinicians to match and generalise the findings of the research to specific clinical populations, all studies in this review specified participant eligibility criteria. Randomly allocating participants to treatment groups minimises the risk of selection bias and decreases the risk that treatment and control groups are not comparable. Five studies removed the risk of selection bias by randomly allocating participants to groups (Aben et al., Shum et al., Bergquist et al., Dowds et al. and Chen et al.). There was a risk, treatment and control groups were not comparable in Potvin et al. and O'Neil-pirozzi et al. Stringer et al. was a within subjects design making randomisation not possible.

The minimisation of inequity between groups and to ensure effects found are solely due to intervention, can be confirmed if a paper reports baseline measures for key outcome measures and prognostic indicators. O'Neill-pirozzi et al. and Dowds et al. were the only studies reviewed that did not report baseline measures for key outcome measures and prognostic indicators, creating the risk of inequity between groups and non-treatment effects.

Blinding is a technique that can be applied to minimise bias. Performance biases are often observed when participants are aware what treatment they are receiving. Participants may perform with less effort if they have knowledge that they are receiving a control intervention. Two studies (Aben et al. and Chen et al.) blinded subjects to treatment conditions removing the risk of performance bias. When therapists are aware of the interventions there is a risk that their performance may vary dependent on the condition they are delivering. Blinding of therapists is particularly difficult in rehabilitation research as therapists will often have a grasp of the theoretical underpinnings of studies, meaning active and control conditions can be easily distinguished. No studies reviewed blinded therapists. Assessors collecting

outcome measures can also be blinded. An assessor having knowledge of the participant group allocation can influence the evaluation process.

Study retention provides information about attrition. Attrition bias can compromise the validity of the study as participants not assessed post intervention may differ from those who are. Four studies obtained at least one key outcome measure for more than 85% of the subjects initially allocated to groups (O'Neil-Pirozzi et al., Potvin et al., Dowds et al., Aben et al.)

Intention to treat analysis is a technique that ensures randomisation is maintained, it allows participants to be analysed in the group they were assigned. Aben et al., Stringer., and Shum et al. ensured bias associated with the non-random loss of participants was controlled.

All studies within the review completed statistical comparisons demonstrating the effectiveness of interventions. Statistical analysis ensures that any differences that have occurred are greater than what can be attributed to chance. Evidence of treatment effects can be evaluated when point measures and measures of variability are reported. All studies bar Stringer reported point measures and measures of variability. It should be noted that not all studies reported the same measures making it difficult to calculate effect sizes that could be used to make direct comparisons between treatment effects in the review.

*Differences between Cicerone et al (2000, 2005, 2011) level of evidence and PED-ro-P*

The PED-ro-P permitted in-depth scrutiny of the methodological quality of the studies reviewed and provided information on how study design can be strengthened in future research. When comparing PEDro-P and Cicerone et al.'s levels of evidence, higher scores on PED-ro-P were generally associated with a better level of evidence rating. Ratings ranged between 6-9/10 for class I studies, 4-5/10 for class IA, 3-4/10 for class II and 3/10 for class III. Class I studies could be distinguished as having a PED-ro-P rating greater than 6/10. There is overlap between ratings of class IA, II and III, suggesting a class IA study could be as well designed as a class II study and a class II study being as well designed as

a class III study. Cicerone et al. make practice recommendations on level of evidence alone suggesting that recommendations made could be based on poorly designed studies and some recommendations may not have been made as it has been assumed that a study has not been as well designed. The level of evidence system neglects the quality of design that can lead to studies being evaluated incorrectly. The PED-ro-P has demonstrated that a lower classed study can be as well designed as a higher classed study. The PED-ro-P offers more precision to the quality rating than the levels of evidence system.

*Memory Rehabilitation Recommendations*

The Cicerone et al. series of reviews make clinical recommendations based on the level of evidence rating using a level of recommendation system (See appendix 1.3). A three tiered model of recommendation is used. *Practice standard,* the highest recommendation, is based on well-designed class I studies with supporting evidence from class II and III studies; *practice guideline* is based on class I studies with design limitations or well-designed class II studies and *practice option* is based on class II and III studies. It is unclear how Cicerone et al. distinguish well designed studies and studies with limitations. Cicerone et al. (2011) made practice standard recommendations for the use of memory strategy training for mild memory impairments from TBI including the use of internalised strategies and external memory compensations were recommended. The current review supports Cicerone et al.'s findings however, the studies reviewed did not evidence if treatment effects continue at follow up, questioning the long term efficacy of interventions. This review also identified some benefits of external compensations consistent with Cicerone et al.'s practice guideline recommendation; however, the present review did not find enough evidence to determine the degree of memory impairment of participants and therefore make formal conclusions in relation to severity of impairment. Memory strategy training over the internet (Berguist et al.) appeared a novel method of delivery. Although no memory improvements were observed between groups, increased use of compensatory strategies and increased family self-report

of improvement suggests that this method of delivery would merit further investigation. The studies reviewed revealed that delivering memory strategy training in a group format has a growing evidence base for all severities of TBI, adding evidence to Cicerone et al.'s practice option recommendation for the use of group based interventions. Future research directly comparing treatment efficacy of individually delivered interventions versus group delivery would be useful. Recommendations are not given for restitution approaches by Cicerone et al. The present review identified some preliminary evidence, suggesting restitution approaches may have some benefit when trying to restore visuospatial memory deficits following right sided stroke, but the treatment effects were not observed at follow-up. The restitution studies reviewed had small sample sizes and did not find effects at follow-up, suggesting there is currently not enough evidence to support this approach for use with TBI and stroke patients. Future well designed research with larger sample sizes may find evidence to support restitution approaches.

*Future Directions of Research*

The evidence base would benefit from better designed studies in all areas of rehabilitation. Studies would benefit from researchers considering the PED-ro-P during research design to ensure biases in methodology are minimised. Rehabilitation research would benefit from establishing a consensus on tools used to measure injury severity for TBI studies. Studies investigating stroke rehabilitation should consider the potential impact of stroke localization on rehabilitation outcome, something not always considered by studies reviewed. Careful consideration needs to be made to ensure control groups are receiving the same intensity and frequency of involvement as intervention groups. Future research would benefit from more explicit consideration of the degree of severity of memory impairment.

The International Classification of Functioning (ICF; WHO, 2001) provides a framework to describe functioning, health and disability. The ICF aims to address the range of domains that a health condition can impact on biologically, socially, psychologically and

environmentally. The majority of studies reviewed measured intervention efficacy through objective memory measures and only a minority considered other factors such as perceived improvement and quality of life. Memory impairments are classified in the ICF but a number of other functional impairments associated with deficits are also considered as pertinent. Future studies may benefit from considering functional difficulties reported in the ICF along with objective memory deficits.

In conjunction with the ICF recommendations it could be argued that neuropsychological tests may not measure functional memory impairments that cause difficulties on a daily basis. Some studies have used personalised tasks to measure efficacy of interventions which may be a more ecologically valid way of measuring the benefits of intervention. However, when using measures personalised to individuals deficits it becomes more difficult to make comparisons between participants and quantify improvements. Future studies may benefit from using both standardised neuropsychological measures and personalised tasks.

*Strengths and limitations of this review*

Using the PEDro-P tool, the methodological quality of studies were evaluated more robustly than previous Cicerone et al. reviews that have used the same search methodology. The PED-ro-P provides a precise critique of study design compared to the method used by Cicerone et al. When using the PEDro-P subjective interpretation may have occurred, despite using an independent rater and the psycBITE database. Clinicians reading this review will be able to compare new studies with the findings using the psycBITE database. Case studies with empirical data were included in this study and labelled as class III evidence following Cicerone et al.'s methodology. The PEDro-P does not allow methodological evaluation of these designs. Tools such as the SCED scale (Tate et al., 2008) have been designed to evaluate the quality of single participant design studies. It would have strengthened this review if such a scale had been used to allow all studies methodological quality to be evaluated.

Adopting the same inclusion and exclusion criteria as previous Cicerone et al. reviews has allowed the author to evaluate this reviews findings with the findings of Cicerone et al.'s studies. Only including participants aged 18-65 years meant any studies investigating memory interventions in over 65's would have been excluded. Arguably, this is appropriate as individuals older than 65 are more likely to have other age related difficulties that may affect memory in addition to TBI or stroke, for example mild cognitive impairment. Therefore, studies including individuals over 65 may find memory interventions are not efficacious due to individuals' co-morbid difficulties. This review only considers one cognitive domain which limits the utility of the document. The reviews that it was based on consider rehabilitation across all domains making the past reviews more comprehensive. The search terms used in this review were developed from the search terms described by Cicerone et al. Truncation of search terms was employed in this review to search for variations in the words used by Cicerone et al. E.g. memor* would have identified articles such as memory, memories, memory's etc. The use of exploded search terms would have further strengthened the search strategy as key words related to the search term would have also been included in the search. Cerebrovascular Accident (CVA) was not used as a search term that could have resulted in the omission of relevant studies utilising this term rather than stroke.

*Conclusion*

The current review found that improvements in memory functioning are observed after the introduction of internal and external compensatory strategies consistent with the Cicerone et al. review series. However, it is unclear if treatment effects are observed at follow up. The results suggest there are benefits in delivering internal compensatory training individually and in groups but there was no evidence found to make recommendations on what approaches are most suitable for varying degrees of memory impairment, as made by the Cicerone et al.'s review series. The present review did not find evidence to support restitution approaches similar to Cicerone et al.'s findings. However, there are some

preliminary findings to suggest restitution approaches may be beneficial restoring impaired memory functioning. More well designed research trials with larger samples need to be conducted to confirm the benefits of restitution before recommendations can be made. Higher PEDro-P scores were associated with higher study class ratings using Cicerone et al.'s levels of evidence criteria. The PED-ro-P provides precision to the criteria used by Cicerone et al. by robustly critiquing the methodological quality of studies and identifying variability in the quality of studies. The introduction of the PED-ro-P in future reviews may change some of the recommendations made in the Cicerone et al. review series because there was high variability in methodological quality between higher classed studies and overlap between methodological quality ratings in lower classed studies. The Cicerone et al. review series may have incorrectly given weighting to some studies and not others as they have relied solely on type of study design neglecting formal assessment of methodological quality. Future research should focus on methodological quality, injury severity and degree of memory impairment. Future reviews would benefit from using a methodology quality rating tool such as the PED-ro-P.

**References**

Aben, L., Heijenbrok-Kal, M. H., van Loon, E. M. P., Groet, E., Ponds, R. W. H. M., Busschbach, J. J. V. et al. (2013). Training memory self-efficacy in the chronic stage after stroke: A randomized controlled trial. *Neurorehabilitation and Neural Repair, 27,* 110-117. http://dx.doi.org/10.1177/1545968312455222

American Association of Neurologic Surgeons (1995). *Guidelines for the management of severe head injury.* New York: Brain Trauma Foundation

Bergquist, T., Gehl, C., Mandrekar, J., Lepore, S., Hanna, S., Osten, A. et al. (2009). The effect of internet-based cognitive rehabilitation in persons with memory impairments after severe traumatic brain injury. *Brain Injury, 23,* 790-799. http://dx.doi.org/10.1080/02699050903196688

Boman, I., Bartfai, A., Borell, L., Tham, K., & Hemmingsson, H. (2010). Support in everyday activities with a home-based electronic memory aid for persons with memory impairments. *Disability & Rehabilitation: Assistive Technology, 5,* 339-350. http://dx.doi.org/10.3109/17483100903131777

Caglio, M., Latini-Corazzini, L., D'Agata, F., Cauda, F., Sacco, K., Monteverdi, S. et al. (2012). Virtual navigation for memory rehabilitation in a traumatic brain injured patient. *Neurocase, 18,* 123-131. http://dx.doi.org/10.1080/13554794.2011.568499

Chen, P., Hartman, A. J., Priscilla Galarza, C., & DeLuca, J. (2012). Global processing training to improve visuospatial memory deficits after right-brain stroke. *Archives Of Clinical Neuropsychology: The Official Journal Of The National Academy Of Neuropsychologists, 27,* 891-905. http://dx.doi.org/10.1093/arclin/acs089

Cicerone, K.D., Dahlberg, C., Kalmar, K., et al (2000). Evidence-based cognitive rehabilitation: recommendations for clinical practice*. Archive Physical Medicine Rehabilitation, 81*, 1596-1615. http://dx.doi.org/10.1053/apmr.2000.19240

Cicerone, K.D., Dahlberg, C., Malec, J.F., et al. (2005). Evidence-based cognitive rehabilitation: updated review of the literature from 1998 through 2002 *Archive Physical Medicine Rehabilitation, 86,* 1681-1692. http://dx.doi.org/10.1016/j.apmr.2005.03.024

Cicerone, K.D., Azulay, J., & Trott, C. (2009). Methodological quality of research on cognitive rehabilitation after traumatic brain injury*. Archives of Physical Medicine Rehabilitation,* 90, S52-59. http://dx.doi.org/10.1016/j.apmr.2009.05.019

Cicerone, K.D., Langenbahn, D.M., Braden, C., Malec, J.F., Kalmar, K., Fraas, M., et al. (2011). Evidence-based cognitive rehabilitation: updated review of the literature from 2003 through 2008. 2002. *Archive Physical Medicine Rehabilitation, 92*, 519-530. http://dx.doi.org/10.1016/j.apmr.2010.11.015

Dowds, M. M., Lee, P. H., Sheer, J. B., O'Neil-Pirozzi, T. M., Xenopoulos-Oddsson, A., Goldstein, R. et al. (2011). Electronic reminding technology following traumatic brain injury: effects on timely task completion. *The Journal Of Head Trauma Rehabilitation, 26,* 339-347. http://dx.doi.org/10.1097/HTR.0b013e3181f2bf1d

Held, J.M. & Pay, T. (1999).Recovery of function after brain damage. In H. Cohen. (Ed.), *Neuroscience for rehabilitation*, Philadelphia, PA: Lippincott Williams & Wilkins.

Jang,H., Youl, J., Hyun, J., YoungTak, K., Jeong Pyo, S., & Woo Hyuk, J. (2013). The Effect of a Memory Training Application for a Patient with Traumatic Brain Injury. *Journal of Physical Therapy Science, 25,* 143-146. http://dx.doi.org/10.1589/jpts.25.143

Kapur, N. (1988). *Memory disorders in clinical practice.* London: Butterworth.

Maher, C.G., Sherrington, C., Herbert, R.D., Moseley, A.M., & Elkins, M. (2003). Reliability of the PEDro Scale for rating quality of randomized controlled trials. *Physical Therapy, 83*, 713-721.

Lezak, M.D., Howieson, D.B., & Loring, D.W. (2012). *Neuropsychological Assessment (5th ed.).* New York: Oxford University Press.

O'Neil-Pirozzi, T. M., Strangman, G. E., Goldstein, R., Katz, D. I., Savage, C. R., Kelkar, K. et al. (2010). A controlled treatment study of internal memory strategies (I-MEMS) following traumatic brain injury. *The Journal Of Head Trauma Rehabilitation, 25,* 43-51. http://dx.doi.org/10.1097/HTR.0b013e3181bf24b1

Potvin, M. J., Rouleau, I., Sénéchal , G., & Giguère, J. F. (2011). Prospective memory rehabilitation based on visual imagery techniques. *Neuropsychological Rehabilitation, 21,* 899-924. http://dx.doi.org/10.1080/09602011.2011.630882

Psychological Database for Brain Impairment Treatment Efficacy (psycBITE;2013). www.psycbite.com

Rees, L., Marshall, S., Hartridge, C., Mackie, D., & Weiser, M.; Erabi Group. (2007). Cognitive interventions post acquired brain injury. *Brain Injury 2007,21,* 161-200

Rohling, M.L., Faust, M.E., Beverly, B., & Demakis, G. (2009). Effectiveness of cognitive rehabilitation following acquired brain injury: a metaanalytic re-examination of Cicerone et al.'s (2000, 2005) systematic reviews. *Neuropsychology, 23,* 20-39. http://dx.doi.org/10.1037/a0013659

Scottish Intercollegiate Guidelines Network (SIGN,130) (2013). *Brain injury rehabilitation in adults.* Edinburgh: SIGN

Shum, D., Fleming, J., Gill, H., Gullo, M., & Strong, J. (2011). A randomized controlled trial of prospective memory rehabilitation in adults with traumatic brain injury. *Journal of Rehabilitation Medicine 43,* 216-223. http://dx.doi.org/10.2340/16501977-0647

Stringer, A. Y. (2011). Ecologically-oriented neurorehabilitation of memory: robustness of outcome across diagnosis and severity. *Brain Injury, 25,* 169-178. http://dx.doi.org/10.3109/02699052.2010.541894

Tate, R. L., Perdices, M., McDonald, S., Togher, L., Moseley, A., & Winders, K., et al. (2004). Development of a database of rehabilitation therapies for the psychological consequences of acquired brain impairment. *Neuropsychological Rehabilitation, 14,* 517-534. http://dx.doi.org/10.1080/09602010343000182

Tate, R., McDonald, S., Perdices, M., Togher, L., Schultz, R. & Savage, S. (2008). Rating the methodological quality of single-subject designs and n-of-1 trials: Introducing the Single-Case Experimental Design (SCED) Scale. *Neuropsychological Rehabilitation,18,* 385-401. http://dx.doi.org/10.1080/09602010802009201

Woolf, S.H. (1992). Practice guidelines, a new reality in medicine: II. Methods of developing guidelines. *Archives of Internal Medicine,* 152, 956-962. http://dx.doi.org/10.1001/archinte.1992.00400170036007

World Health Organisation. (2001) International Classification of Functioning, Disability and Health. Geneva: World Health Organization

# CHAPTER 2: MAJOR RESEARCH PROJECT

## *Are Sleep Difficulties Associated with Cognitive Functioning Following Acquired Brain Injury in an In-Patient Neuro-rehabilitation Population?*

## *A Preliminary Study*.

Allan Stuart Thomson*

***Submitted in partial fulfilment of the requirements for the degree of***

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Address for correspondence:

Allan Stuart Thomson

Academic Unit of Mental Health and Wellbeing

University of Glasgow

Gartnavel Royal Hospital

1055 Great Western Road

Glasgow, G12 0XH

Email: allan.thomson1@nhs.net

*Corresponding author.

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**Lay Summary**

Researchers report that attention, memory and executive function can be affected by sleep difficulties in healthy adults. Attention is the ability to focus on a task. Memory is the ability to retain and recall information over time. Executive functions are the cognitive processes that regulate an individual's ability to organise thoughts and activities, prioritise tasks, manage time efficiently, and make decisions. After an Acquired Brain Injury (ABI) people often experience difficulties with attention, memory and executive functioning. An ABI is an injury to the brain that can occur as a result of an external force to the head or illness. People who have a severe ABI often need to engage in in-patient rehabilitation. Recently researchers have discovered that attention problems can be made worse by sleep disturbance following ABI. This study investigates whether sleep difficulties affects attention, memory and executive functioning problems in people who have ABI and are inpatients in a rehabilitation unit. Participants were recruited from two rehabilitation hospitals and discussed their current sleep pattern with a member of the research team. Participants then wore an Actiwatch (an electronic device that measures movement) for 7 days. The data collected by Actiwatches can be used by researchers to determine if someone is asleep or awake. After wearing the Actiwatch researchers met with participants again and completed tests designed to measure attention, memory and executive functioning. This study found that people with an ABI that report poor sleep have better memory than those who report good sleep. This may be because participants who have a better memory are more aware of sleep problems they have. Poor sleep did not appear to affect attention and executive functioning adversely in this study. Further research needs to be completed with more participants and more sophisticated equipment to monitor sleep.

**Abstract**

**Background:** Sleep loss can impair cognition in healthy adults (Waters & Bucks, 2011). Poor sleepers post head injury (HI) have significantly worse sustained attention than good sleepers post HI (Bloomfield et al., 2010, Sinclair et al., 2013).

**Aims:** The present study explores the relationships between objective and subjective sleep measures and overall cognitive functioning, sustained attention, memory and executive functioning in people with an Acquired Brain Injury (ABI) who are currently participating in in-patient neurorehabilitation.

**Methods:** This study has a correlational design with exploratory between groups analyses. Twenty participants were recruited and their sleep was assessed using a subjective (Pittsburgh Sleep Quality Index; PSQI) and an objective (Actigraphy) measure of sleep. Cognitive tests were completed to determine current cognitive functioning on specific cognitive domains.

**Results:** Self-reported sleep difficulties were associated with better overall cognitive functioning ($r=0.46$, $N=20$, $p=0.04$) and memory domain scores ($r=0.50$, $N=20$, $p=0.01$). No associations were found between Actigraphy and cognitive performance. There were discrepancies between subjective and objective sleep measures in 45% of participants. 67% of participants with discrepancies between sleep measures under reported poor sleep and 33% over reported poor sleep when compared to an objective measure. Exploratory analysis of clearly good and poor sleepers, defined by congruent objective and subjective sleep measures, revealed poor sleepers have significantly better memory cognitive domain scores than good sleepers ($t(9)=2.27$, $p=0.049$;$d=1.37$).

**Conclusions/Recommendations:** The phenomenon of poor sleep and better memory performance may be explained by poor sleepers having better memory for their difficulties post injury than good sleepers or increased awareness of their current sleep patterns because their memory is better preserved. Clinicians should adopt an objective measure of sleep in addition to subjective measures of sleep when assessing sleep difficulties in an in-patient neurorehabilitation population. Patients who do not report sleep difficulties may in fact be experiencing sleep problems that that could impact on their neurorehabilitation schedule.

## Introduction

### *Acquired Brain Injury, Sleep Difficulties[1] and Rehabilitation*

The incidence of sleep disturbances after Acquired Brain Injury[2] (ABI) ranges from 27% to 72.7% (Maclean et al., 1993; Makley et al., 2008; Cohen et al., 1992). Individuals with sleep difficulties and an ABI can experience exacerbated pain, cognitive deficits, fatigue or irritability and sleep difficulties may slow the recovery process (Ouellet & Morin, 2004). Sleep difficulties after ABI are often under reported by healthcare professionals, as other sequelae associated with injury are classed as more pertinent in the rehabilitation process (Ouellet & Beaulieu-Bonneau, 2009).

It is not clear if the severity of ABI is directly associated with insomnia. Studies show that milder ABI is associated with an increased prevalence of insomnia (Clinchot et al., 1998; Fictenberg et al., 2001) whereas other studies note an increased prevalence of insomnia with increasing injury severity (Cohen et al., 1992). Some researchers have suggested that individuals with milder injuries are more aware of their sleep difficulties and over report problems whereas individuals who have sustained more severe injuries under report sleep disturbance (Elovic et al., 2005). Orff et al. (2009) reviewed the literature regarding the prevalence and consequences of sleep disturbance following ABI, finding discrepancies in

[1]Sleep difficulties in this study are operationally defined by subjectively reported and/or objectively measured sleep disturbance. Subjectively a score of greater than or equal to 6 (Mahmood et al. 2004) on the Pittsburgh Sleep Quality Index (PSQI) is indicative of sleep difficulties and objectively a sleep efficiency score, measured by Actigraphy, of less than 85% (Sadeh & Acebo 2002) is indicative of sleep difficulties.

[2] *"ABI implies damage to the brain that was sudden in onset and occurred after birth and the neonatal period. It is thus differentiated from birth injuries, congenital abnormalities and progressive or degenerative diseases affecting the central nervous system* (Scottish Needs Assessment Programme Report, 2000)." *"This definition permits the inclusion of open or closed traumatic head injuries, and non-traumatic causes, such as vascular incidents (e.g. stroke), infection (e.g. meningitis), hypoxic injuries (e.g. cardiorespiratory arrest), or toxic or metabolic insult (e.g. hypoglycaemia)." (SIGN 130, 2013 p.2)*

the conclusions made between studies that have used objective and subjective measures to characterise sleep difficulties.

After a severe ABI, inpatient rehabilitation is often required, where engagement in an interactive process with professional staff, relatives and members of the wider community is required to achieve optimum physical, psychological, social and vocational well-being (McLellan, 1991). Makley et al. (2008) studied the prevalence of sleep wake cycle disturbance in head injury (HI) patients in an inpatient rehabilitation facility. They found that HI patients with sleep disturbance stayed longer in rehabilitation centres than those with no sleep difficulties.

***Cognition, Sleep difficulties and Brain Injury***

Evidence demonstrating a close relationship between sleep loss and cognition in healthy adults is growing (Waters & Bucks, 2011). These authors highlighted that sleep loss and cognition reliably produce impairments in speed of processing and attention. Higher order cognitive functions such as memory and executive functions are also affected to a lesser extent by sleep loss. 'Crystallised' cognitive abilities such as language tasks that rely on retrieval of acquired knowledge appear to remain preserved after sleep loss.

Shekleton et al. (2010) reviewed studies to investigate which cognitive domains are most consistently impaired in healthy adults with primary insomnia. They note that studies have produced inconsistent and sometimes conflicting findings. Consistent with sleep deprivation studies, attention and working memory tasks show deficits in participants with insomnia. A meta-analysis by Fortier-Brochu et al. (2012) provides a quantitative summary of the magnitude of differences on neuropsychological test performance between primary insomniacs and normal sleepers. Significant impairments of a small to moderate size were found on tasks of episodic memory, problem solving, and working memory. No significant group differences were observed in tasks of general cognitive function, perceptual and psychomotor processes, procedural learning, verbal functions, dimensions of attention and

in some aspects of executive functioning. The results of the meta-analysis are inconsistent with Shekleton et al.'s review. Methodological variations and different definitions of insomnia are likely to have contributed to inconsistencies. Killgore (2010) explained that some of the tests used are well suited to detect severe levels of brain damage, but may not demonstrate adequate sensitivity for detecting deficits and instability of performance that may accompany sleep loss. This suggests reduced performance in cognition may accompany sleep loss but may not always be detected by assessment.

Unless an ABI is very mild, cognitive deficits are generally observed in individuals who have experienced trauma to the brain. Problems with memory, attention, executive functioning and speed of processing are the most typical cognitive difficulties encountered after ABI (Wilson, 2008). Cognitive deficits after ABI have a greater negative impact on quality of life than physical disabilities alone (Eslinger et al., 2002). Cicerone et al. (2005) concluded that there is a substantial evidence base demonstrating that patients with HI benefit from cognitive rehabilitation. They propose that further research should move on from investigating whether cognitive rehabilitation is effective, to examine patient characteristics that optimise outcomes of cognitive rehabilitation.

Recently, a number of studies have been completed investigating the relationship between sleep and sustained attention in individuals who have sustained a HI. Bloomfield et al. (2010) found that poor sleepers post HI had significantly poorer sustained attention than good sleepers post HI using the Sustained Attention to Response Test (SART). Sinclair et al. (2013) investigated Psychomotor Vigilance Test (PVT) performance in individuals who had sustained a HI compared to healthy controls. The HI group had longer mean reaction times with reports of poor sleep quality and fatigue. Mahmood et al. (2004) reviewed archived neuropsychological tests and self-report sleep scores for HI patients and found that reports of sleep disturbance were associated with intact executive functioning and suggested self-

reporting poor sleepers may have more insight into their deficits. It should be noted Mahmood et al. (2004) relied solely on subjective reports of sleep.

### *The Present Study*

There is growing evidence to suggest that sustained attention deficits post HI are associated with sleep disturbance (Bloomfield et al., 2010; Sinclair et al., 2013). Studies investigating sleep disturbance and cognition in healthy adults consistently reveal sustained attention deficits, and to a lesser extent memory and executive functions deficits, are associated with sleep disturbance. The most common impairments observed in ABI patients in rehabilitation centres are impairments of memory, attention, executive functioning and speed of processing (Wilson, 2008). Although the cognitive domains in which impairments are found after ABI and in non-brain injured people with sleep problems are similar, there is a question over whether sleep problems add to cognitive deficits found after severe ABI. There is evidence to suggest that people who have sustained a severe ABI may under report sleep difficulties (Elovic et al. 2005) that creates a need for objective and subjective measure of sleep to be considered separately. This is the first study to investigate if sleep difficulties, defined by an objective and subjective measure, exacerbate existing impairments in sustained attention, memory and executive functioning post ABI.

**Aims and Hypothesis**

To explore the relationship between an objective and subjective sleep measure and overall cognitive functioning, and in the cognitive domains of sustained attention, memory and executive functioning in people with an ABI who are participating in inpatient rehabilitation.

*Hypotheses*

*Primary -*

1. The Pittsburgh Sleep Quality Index Score (PSQI) will be negatively correlated with overall cognitive functioning, sustained attention, memory and executive functioning.
2. Sleep efficiency[1] will be positively correlated with overall cognitive functioning, sustained attention, memory and executive functioning.

*Secondary–*

1. Sleepiness[2] will be negatively correlated with overall cognitive function for all participants.
2. PSQI score will be negatively correlated with cognitive tests individual subtests scores.
3. Sleep efficiency will be positively correlated with cognitive tests individual subtests scores.

*Exploratory-*

[1] Sleep efficiency is the total time asleep divided by the total time spent in bed multiplied by 100. This information was collected through Actigraphy and then calculated using an auto calculate algorithm on the Actigraphy analysis software.

[2] Sleepiness is defined as how tired someone feels at the time of assessment. In this study sleepiness is quantified using the Stanford Sleepiness Scale (SSS).

1. Poor sleepers will have lower overall cognitive functioning scores, sustained attention, memory and executive functioning than good sleepers.

## Method

### *Ethical approval*

Ethical approval was obtained from the NHS West of Scotland Research Ethics Committee 3 (See appendix 2.2). Further approval was obtained from NHS Lanarkshire Research and Development Department, Huntercombe Research and Development Department and the Clinical Director at The Brain Injuries Rehabilitation Trust, Graham Anderson House.

### *Design*

A correlational design was used to explore the relationships between a subjective and objective sleep measure and overall cognitive functioning, sustained attention, memory and executive functions (working memory, verbal fluency, problem solving and inhibition) in individuals who have sustained an ABI and are in-patients in a neurorehabilitation centre. A between groups, exploratory analysis between poor and good sleepers cognitive test performance was also employed.

*Inclusion criteria*

18-64 years old, with a moderate to severe ABI, who were inpatients in a neurorehabilitation centre for at least 3 weeks, settled into the rehabilitation schedule and considered to have the capacity to consent.

*Exclusion criteria*

People were excluded if they had a learning disability, severe psychiatric symptoms, on-going substance misuse or impairments of language or perception, in the judgement of the clinical team or researcher that would make the tests or interview invalid. If the clinical team/ researcher identified the person as not having the capacity to consent to research or had on-going physical health problems that would make it difficult for them to engage in the research

process they were excluded. Any person fitting The International Classification of Sleep Disorders- II (ICSD-II, 2005) criteria for sleep apnoea, narcolepsy, restless legs syndrome or periodic limb movement disorder were excluded because the mechanisms associated with these disorders could impact on cognition in a different way to other sleep problems.

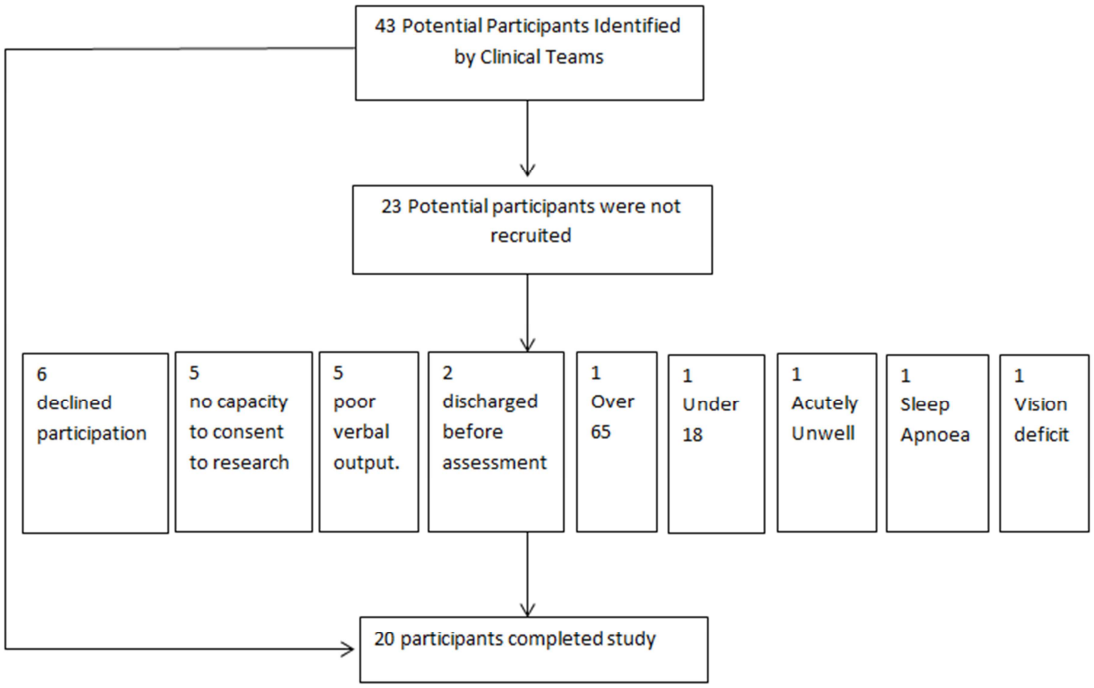
*Recruitment Procedures*

Two methods of recruitment were employed:

1. Rehabilitation centre staff were briefed on the details of the study by the research team. Rehabilitation staff identified participants they believed met the inclusion criteria and obtained verbal consent for the researchers to discuss the study with the patients. Researchers provided potential participants with information about the study and if interested they completed a consent form.

2. Participants who met the inclusion criteria were recruited when their participation in a research study investigating the epidemiology of sleep problems in an inpatient neurorehabilitation closed head injury population, was ending. Rehabilitation centre staff identified participants they believed met the inclusion criteria, and obtained verbal consent for the researchers to discuss this study when their participation in the epidemiology study ended. When participation in the epidemiology study was ending, potential participants who met the research criteria were asked if they would like information about this study. If interested, they were provided with information and completed a consent form at least 48 hours after participation in the epidemiology study. No participant was enrolled in two studies at one time. The epidemiology study used the same sleep measures included in this study and participants were asked if the information collected in the previous study could be used by researchers. See Figure 1, illustrating participant recruitment and identification.

**Figure 1: Participant recruitment and identification flow chart**




## Measures

*Background Measures of mood and cognition*

- The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983)

The HADS is a self-report measure of depression and anxiety that has 7 questions relating to depression and 7 questions relating to anxiety. Dawkins et al. (2006) concluded the HADS is a useful tool in examining depression and anxiety in ABI populations. Bjelland et al. (2002) reviewed 747 articles examining HADS validity. The review found HADS anxiety scores to have a mean Cronbach's alpha of 0.83 and HADS depression score to have a mean Cronbach's alpha of 0.82, indicating high internal consistency.

- Vocabulary, Matrix Reasoning, Block Design and Similarities subtests from Wechsler Adult Intelligence Scale, 4$^{th}$ Edition (WAIS IV, Wechsler, 2008).

The WAIS IV subtests were administered to provide information about current intellectual functioning.

*Sleep Measures*

- Semi Structured Clinical Interview

A semi structured interview based on the International Classification of Sleep Disorders-II (ICSD-II) was conducted to identify sleep disorders that did not meet the inclusion criteria. The semi structured Interview was developed by Morfiri (2013) adapting the Duke Structured Interview for Sleep Disorders, including factors that may have been pertinent to individuals with ABI. The Duke Structured Interview for Sleep Disorders has been shown to have acceptable reliability and validity for insomnia diagnosis (Edinger et al. 2009).

- The Pittsburgh Sleep Quality Index (PSQI; Buysse et al.,1989)

The PSQI is a global measure of sleep quality. Participants are asked to select response from a 0-3 likert scale for 19 questions relating to seven clinically derived domains of sleep difficulties; sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication and day time dysfunction. Buysee et al. (1989) found the PSQI to have a Cronbach's alpha coefficient of 0.83, indicating high internal consistency. A cut off score of 6 or greater has been validated as differentiating between HI patients with and without sleep disturbance (Mahmood et al., 2004).

- Actigraphy

Actigraphy was used as an objective measure of sleep. Actigraphy involves a person wearing an 'Actiwatch' which is a device that looks like a wrist watch and records movement over time. Actiwatch Sleep 2001 software was used to automatically calculate sleep efficiency after the participant had worn an 'AW4' Actiwatch for 7 days. The auto calculate function is particularly useful when assessing individuals with inadequate perception of sleep (Souza et al., 2003). There are however, some limitations to this approach as it cannot be confirmed if the person was definitely asleep or awake. Sadeh & Acebo (2002) have shown that Actigraphy is a satisfactory objective estimate of sleep and sleep efficiency scores of less than 85% are indicative of poor sleep.

- Stanford Sleepiness Scale (SSS; Hoddes et al., 1972)

A measure of sleepiness at the time of assessment. The SSS contains seven statements describing levels of sleepiness and participants are asked to select the statement that best refers to their current level of sleepiness. Following 24 hours of total sleep deprivation SSS scores have been found to be significantly elevated. (Hoddes et al.,1973). Research has also found the SSS can predict performance on tasks relating to alertness (Broughton, 1982).

***Measures of cognitive function***

*Selection of Tests*

Cognitive tests were selected on the basis of their ability to distinguish cognitive changes resulting from sleep difficulties in head injured and non-head injured individuals and their availability to the research team (see table 1).

*Sustained Attention*

- The Sustained Attention to Response Test (SART; Robertson et al., 1997)

The SART is a measure of sustained attention. Participants were presented with single digits (1-9) in a quasi-random sequence on a computer screen. Participants responded to all digits with the exception of the number 3, where they had to withhold a response. Participants registered responses pressing the spacebar, on a Toshiba laptop computer. Performance was measured by recording errors of commission, errors of omission and average reaction times. The SART was programmed in E-Prime software. Robertson et al. suggested the test had good test-retest reliability showing scores over two testing sessions were correlated (0.76) suggesting stability over time. They also demonstrated good concurrent validity as the test significantly correlated with other tests of sustained attention.

- Psychomotor Vigilance Test (PVT, Altena et al., 2008)

Participants pressed the left mouse button on a Toshiba laptop computer in response to 110 asterisks that were presented sequentially at random intervals between 1 and 10 seconds on the same location of a computer screen. Performance was measured by recording percentage accuracy and average reaction time. The PVT was programmed in E-Prime software. Psychometric properties were not available for this version of the PVT. The version of the test has been consistently used in sleep studies.

*Executive Functions*

- Letter Number Sequencing *(LNS) ( Working memory; Lezak et al., 2004)*

Letter number sequencing required participants to temporarily store and perform cognitive operations on information. A number of jumbled up letters and numbers were presented e.g. (A 2 B 5). Participants ordered the numbers numerically and letters alphabetically e.g. (2 5 A B). Performance was measured by recording the number of correct responses. LNS shows good concurrent validity with arithmetic, symbol search and visuospatial learning tests assessing working memory (Crowe, 2000).

- FAS (*Verbal fluency; Lezak et al., 2004)*

Participants produced as many words as they could, excluding proper nouns and derivatives of the same word (e.g. eat, eating, eaten), on three 1 minute trials when presented with the letters F, A and S. The total number of valid words recalled and perseveration errors (repetition of responses) were recorded to measure performance. Young adults were found to have a test re-test reliability of 0.84 (Ross et al. 2007).

- Modified Six Elements Test (mSET) (*problem solving, creative thinking and planning;* Wilson et al., 1996)

The mSET is a measure of supervisory control of executive functioning and everyday functioning. Participants completed 3 tasks, storytelling, simple arithmetic and object naming. Each task consisted of two sub tests and subjects were instructed not to do the two related sub tests consecutively. A time limit of 10 minutes was set and participants were encouraged to complete some of each task. The tasks had a maximum score of 6. Points were deducted when the rules were broken and/ or a subject spent more than 271 seconds on one of the 6 sub tests. The mSET is reported to have good ecological validity (Burgess et al. 2006).

- Hayling Sentence Completion Task (*Inhibition; Burgess & Shallice, 1996)*

The Hayling sentence completion task measures the capacity to inhibit strong associations in favour of novel responses. The Hayling test consisted of two parts. Initially, participants were presented with a sentence with the last word missing and they provided a word that gave a congruent ending. In the second task participants were presented with a similar sentence, as in part 1 and asked to provide an incongruent response. Response times, number of errors and overall score were recorded to measure performance. The Hayling test scores have been shown to have good test re-test reliability 0.52-0.78 (Burgess & Shallice 1996). The test scores were also been shown to have good split half reliabilities in impaired individuals 0.72-0.93.

*Memory*

- Rey Auditory and Verbal Learning Test (RAVLT; Rey, 1941)

A 15 word list was read to the participant 5 times and after each presentation of the list an immediate recall task followed. After 30 minutes, participants completed a delayed free recall task. Participants were then presented with a recognition trial from a list of 50 words. Words recalled immediately, after a time delay, in a recognition trial and the number of false positives in the recognition trial were recorded to measure performance. Powell et al. (1991) suggested the RAVLT had better discriminant validity than the Halstead-Reitan measures, Stroop and logical or visual reproduction in the Wechsler Memory Scale. The test has also been shown to have high test re-test reliability (Lezak et al. 2004)

**Establishing cognitive domains**

Test scores were selected for their ability to detect differences between ABI and controls (See table 1). They were standardised to a z-score, and scores corresponding to each domain were averaged to create 3 composite cognitive domains scores. An overall cognitive function domain was then calculated by averaging the sustained attention, executive functioning and memory composite scores (Whitnall et al., 2006; Crawford & Garthwaite,

2002). Note, that where negative scores indicated better performance, they were transformed to positive z-scores to ease interpretation.

**Table 1. Cognitive tests selected to form composite domain scores.**

| **Composite Sustained Attention** | **Composite Memory** | **Composite Executive functioning** |
|---|---|---|
| SART Error of Commission (Bloomfield et al., 2010) | RAVLT Immediate Recall (Campos-Morales et al., 2005) | FAS Total (Harrison & Horne, 1997) |
| SART Error of omission | RAVLT Delayed Recall | LNS Total (Gradisar et al., 2008) |
| SART Reaction Time | RAVLT Recognition | mSET Overall Score (Nilsson et al., 2005) |
| PVT Percentage Accuracy (Altena et al., 2008) | | Hayling Category A Errors (Harrison & Horne, 1998) |
| PVT Reaction Time | | Hayling Category B Errors |
| | | Hayling Response Time Part B |

*Note. SART=Sustained Attention Response Test, PVT= Psychomotor Vigilance Test, RAVLT= Rey Auditory Verbal Learning Test, LNS= Letter Number Sequencing, mSET= Modified Six Elements Test*

**Participant Characteristics**

Participants were recruited from two neurorehabilitation centres – the Brain Injury Rehabilitation Trust, Graham Anderson House and the Brain Injury Rehabilitation Centre, Huntercombe Services, Murdostoun. A total of 20 participants were recruited (see table 2).

**Experimental Procedure**

Participants were interviewed using a semi-structured clinical interview to exclude sleep disorders such as sleep apnoea, narcolepsy, restless leg syndrome and periodic limb movement disorders because the mechanisms associated with these disorders could impact on cognition in a different way to other sleep problems. Suitable participants completed the HADS, PSQI and wore an Actiwatch for seven days. Participants were instructed to complete sleep diaries with rehabilitation centre staff support but were not included in the analysis due to inconsistent completion by staff and participants. It was agreed with participants that the researcher would meet with them again in 7 days to collect the Actiwatch and complete cognitive tests.

Participants who were recruited in the sleep epidemiology study entered the study at this point. They had already completed the sleep interview, HADS, PSQI and Actigraphy in the first study. All participants who participated in the epidemiology study agreed this data could be reused in this study. The data was considered to be an accurate as there were only 1-2 weeks between participation in each study.

Seven days after the first meeting/completion of the epidemiology study the researcher conducted the cognitive tests in a quiet room between 11.00 am and 3.00 pm, where possible, to account for circadian effects on performance. The participants completed the following measures in this order - SSS, RAVLT immediate recall, SART, PVT, LNS, RAVLT delayed recall and recognition, FAS, Hayling sentence completion task and mSET. Some participants completed the measures over a number of meetings to accommodate other activities within the rehabilitation centre. For those who completed measures over a number of days the SSS was completed at the beginning of each assessment session and a mean score was recorded.

Demographic information was collected such as time since injury, cause of injury, age, gender, length of time in rehabilitation and current functioning on WAIS IV subtests from the rehabilitation centres records.

The researchers recorded any cognitive tests included in the research that participants had completed previously and the time that had elapsed since their completion. Seven participants completed the mSET, 9 participants completed FAS and 3 participants completed the Hayling test at least one month before the research and it was not believed that any practice effects would be observed on these assessments.

**Data Analysis**

Statistical analysis was undertaken using IBM, SPSS Statistics Version 19. Descriptive statistics on patient characteristics were reported. Distribution of the data was explored using Shapiro Wilks tests of normality. Pearson correlations were completed for normally distributed data and Spearman correlations for skewed data.

For the purpose of preliminary between group analyses, the criteria used by Bloomfield et al. (2010) to define conservative good and poor sleepers was adapted to create two sleep groups. Five participants with mean sleep efficiency scores of 85% or more and a score of 5 or less on the PSQI were defined as good sleepers. Six participants who had mean sleep efficiency scores of 84% or less and a score of 6 or more on the PSQI were defined poor sleepers. The demographics of each group were reported and the distributions of these variables confirmed using Shapiro Wilks tests of normality. T-tests were completed for normally distributed variables and Mann Whitney tests were completed for not normally distributed demographic variables, to confirm equity between groups. Cognitive domain, dependent variable scores are z-scores and have a mean of 0 and standard deviation of 1 allowing a standard normal distribution to be assumed. Therefore the data met the assumptions for parametric analysis. Independent samples t-tests were used to compare the

differences between poor and good sleepers overall cognitive function, sustained attention, executive functioning and memory.

## Results

*Participant characteristics*

Table 2 describes the demographic and background information for all participants.

**Table 2: Participant Demographic Information (Mean (standard deviation) or frequency)**

| | **Participants (n=20)** |
|---|---|
| **Gender** (Number of Participants) | Male= 18 Female=2 |
| **Age** (Years) | 43.45 (0.31) (Range 23-61) |
| **Time since injury** (Months) | 50.75 (72.84) (Range 3-264) |
| **Time Since Admission** (Months) | 8.5 (7.42) (Range 1-28) |
| **Cause of injury** (Number of participants) | Road traffic accident = 5<br>Fall= 6 Assault= 2<br>Stroke= 1 Infection= 2<br>Hypoxic= 3 Unknown= 1 |
| **Years of Education,** (Years) | 11.75 (1.86) (Range 11-17) |
| **HADS Anxiety** | 6.85 (4.77) |
| **HADS Depression,** | 6.60 (4.37) |
| **SSS** | 2.20 (1.25) |
| **WAIS IV Vocabulary (Scaled Score** | 5.35 (1.78) |
| **WAIS IV Similarities (Scaled Score)** | 4.65 (2.66) |
| **WAIS IV Matrix Reasoning (Scaled Score)** | 5.25 (2.31) |
| **WAIS IV Block Design (Scaled Score)** | 5.4 (2.47) |

*A comparison of subjective and objective measurement of sleep*

The mean PSQI score for all participants was 5.25 (SD= 3.95) and mean sleep efficiency score for all participants was 80.96 % (SD=10.49). There was a significant negative association between PSQI scores and sleep efficiency scores (Pearson, r=-0.45, N=20, p=0.047); self-report of poorer sleep (higher PSQI scores) are associated with poorer sleep efficiency (Actiwatch). Examination of individual sleep efficiency and PSQI scores in relation to cut offs for poor sleep (PSQI ≥6, Sleep Efficiency ≤84= Poor Sleep and PSQI ≤5, sleep Efficiency ≥85= Good Sleep) was used to determine poor and good sleep, and revealed some discrepancies between PSQI and Sleep Efficiency. Nine participants had PSQI and sleep efficiency scores that contradicted each other; 3/9 participants scored greater than or equal to 6 on the PSQI indicative of poor sleep, but over 85% on sleep efficiency indicative of good sleep and 6/9 participants scored 5 or less on the PSQI indicative of good sleep but had sleep efficiency scores of less than 85% indicative of poor sleep.

***Primary hypotheses***

1. *Pittsburgh Sleep Quality Index Score (PSQI) will be negatively correlated with overall cognitive functioning, sustained attention, memory and executive functioning.*

Table 3 illustrates Pearson correlations between cognitive domain scores and sleep self-report for the total sample and participants with a congruent PSQI score and sleep efficiency. There was a significant association between PSQI scores and Overall Cognitive Functioning for the total sample (r=0.46, N=20, p=0.04) indicating that higher PSQI scores, (indicative of poor sleep), were associated with better Overall Cognitive Functioning Scores. There was also a significant association between PSQI scores and memory domain scores for the total sample (r=0.50, N=20, p=0.01) showing higher PSQI scores, indicative of poor sleep, were associated with better memory domain scores. A significant association was also found between PSQI and memory domain scores for participants with congruent PSQI scores and sleep efficiency (r=0.67, N=11 p=0.02). Again, higher PSQI scores, indicative of poor sleep, were associated with higher memory domain scores, indicative of better performance.

**Table 3. Self-report of sleep quality and cognitive domain scores**

| **Cognitive Domain** | **PSQI : Total sample (n=20)** | **PSQI : Participants with congruent sleep measures (n=11)** |
|---|---|---|
| Overall Cognitive Functioning | **r=0.46 , p=0.04** | r= 0.59, p=0.55 |
| Sustained Attention | r=0.09, p=0.70 | r=0.01, p=0.97 |
| Memory | **r= 0.50, p=0.01** | **r=0.67, p=0.02** |
| Executive Functioning | r= 0.26, p=0.27 | r=0.39, p=0.23 |

*Note. PSQI= Pittsburgh Sleep Quality Index, n= number, r= Pearson Correlation Coefficient, p= p-value*

*Significant associations highlighted in **bold***

2. *Sleep efficiency will be positively correlated with overall cognitive functioning, sustained attention, memory and executive functioning.*

Table 4 illustrates Pearson correlations between cognitive domain scores and sleep efficiency for the total sample and participants with a congruent sleep efficiency and PSQI score. No associations between sleep efficiency and cognitive domains were identified.

**Table 4. Sleep efficiency and cognitive domain scores**

| **Cognitive Domain** | **Actigraphy, Sleep efficiency: Total sample (n=20)** | **Actigraphy, Sleep efficiency: Participants with congruent sleep measures (n=11)** |
|---|---|---|
| Overall Cognitive Functioning | r=-0.18, p=0.45 | r=-0.31, p=0.35 |
| Sustained Attention | r= 0.19, p=0.41 | r=0.21, p=0.54 |
| Memory | r= -0.36, p=0.12 | r=-0.52, p=0.10 |
| Executive Functioning | r= 0.009, p=0.97 | r=-0.65, p=0.85 |

*Note. n=number, r= Pearson Correlation Coefficient, p= p-value*

*Potential Confounding Variables*

Pearson correlations revealed no significant associations between HADS depression scores and overall cognitive functioning (r=-0.14, N=20, p=0.57), sustained attention (r= 0.12, N=20, p=0.62), executive functioning (r=-0.16, N=20, p=0.49) or memory (r=-0.17, N=20, p=0.49). No significant associations were found between HADS anxiety scores and overall cognitive function (r=0.27, N=20, p=0.25), sustained attention (r= 0.12, N=20, p=0.62), executive

functioning (r=0.28, N=20, p=0.23) or memory (r=0.16, N=20, p=0.50). No significant associations were found between participants age and overall cognitive functioning (r=-0.22, N=20, p=0.35), sustained attention (r=-0.18, N=20, p=0.46), executive functioning (r=-0.10, N=20, p=0.68) or memory (r=-0.21, N=20, p=0.35).

Spearman correlations revealed no significant associations between WAIS IV vocabulary scores and overall cognitive functioning (r=0.39, N=20, p=0.08), sustained attention (r=0.29, N=20, p=0.22), memory (r=0.27, N=20, p=0.25) or executive functioning (r=0.44, N=20, p=0.06). No associations were found between number of years in education and overall cognitive functioning (r=-0.14, N=20, p=0.56), sustained attention (r=0.20, N=20, p=0.40), memory (r=-0.33, N=20, p=0.15) or executive functioning (r=0.23, N=20, p=0.33). No associations were found between number of months since injury and overall cognitive functioning (r=0.29, N=20, p=0.22), sustained attention (r=0.25, N=20, p=0.30), memory (r=0.29, N=20, p=0.21) or executive functioning (r=0.21, N=20, p=0.37). No associations were found between months since admission to neurorehabilitation unit and overall cognitive functioning (r=0.03, N=20, p=0.91), sustained attention (r=0.09, N=20, p=0.72), memory (r=0.08, N=20, p=0.73) or executive functioning (r=-0.11, N=20, p=0.65).

***Secondary hypotheses***

1. *Sleepiness will be negatively correlated with overall cognitive function for all participants*.

Spearman correlations revealed no significant associations between SSS scores and overall cognitive function (r= -0.22, N=20, p=0.35), sustained attention (r= -0.21, N=20, p=0.38), executive function (r= -0.25, N=20, p=0.29) or memory (r=-0.16, N=20, p=0.50).

2. *PSQI score will be negatively correlated with individual cognitive subtest scores.*

Significant positive associations were found between PSQI scores for all participants and mSET total score (r= 0.47,N=20, p= 0.04), RAVLT immediate recall (r= 0.48, N=20 p= 0.03) and RAVLT delayed recall (r= 0.52,N=20, p= 0.02). These correlations signify that worse

self-ratings of sleep were associated with better performance on mSET, RAVLT immediate recall and RAVLT delayed recall. Non-significant associations are reported in Appendix 2.10.

3. *Sleep efficiency will be positively correlated with individual cognitive subtests scores*.

A significant negative association was found between sleep efficiency and SART errors of commission (r= -0.7, N=20, p=0.001). Suggesting low sleep efficiency scores, indicative of poorer sleep, were associated with a lower number of SART errors of commission scores, showing poorer sleep was associated with better performance. A significant positive association was found between sleep efficiency and SART average reaction time (r=0.49, N= 20, p=0.03). This suggests low sleep efficiency, indicative of poorer sleep, was associated with slower reaction time, indicative of poorer performance. Non-significant associations are reported in Appendix 2.10

***Exploratory Analysis***

To examine differences in characteristics between the 6 poor and 5 good sleepers, comparisons were made between demographic and background variables. Differences between groups were not significant in age (t(9)=-0.69, p=0.51), years in education (U=21.0, p=0.10), time since injury (U= 13.0, p=0.71), time since admission (t(9)=0.45, p=0.66), HADS depression score (U=16, p=0.85), HADS anxiety score (t(9)= 0.23, p=0.38), WAIS IV Vocabulary (t(9)= 0.35, p=0.86), WAIS IV Similarities (t(9)= 0.6, p=0.41), WAIS IV Matrix Reasoning (t(9)= 0.12, p=0.34) or WAIS IV Block Design (t(9)= 0.9, p=0.40) .

1. *Poor sleepers will have lower overall cognitive functioning scores, sustained attention, memory and executive functioning than good sleepers.*

Poor sleepers had significantly better memory scores than good sleepers (t(9)=2.27, p= 0.049) and there was no difference for other domains (see table 5).

**Table 5. Measures of central tendency and Independent t- tests comparing poor and good sleeper's performance on each cognitive domain**

| Cognitive Domain | Poor Sleepers Mean (SD) (n=6) | Good Sleepers Mean (SD) (n=5) | t | df | p | Effect Size d[1] |
|---|---|---|---|---|---|---|
| Overall Cognitive Functioning | 0.23 (0.51) | -0.16 (0.42) | 1.36 | 9 | p=0.21 | 0.85 |
| Sustained Attention | -0.08 (0.46) | 0.06 (0.28) | -0.58 | 9 | p=0.57 | -0.37 |
| Memory | 0.62 (0.82) | -0.52 (0.85) | 2.27 | 9 | p=0.049 | 1.37 |
| Executive Functioning | 0.14 (0.53) | -0.01(0.40) | 0.54 | 9 | p=0.61 | 0.32 |

[1] Cohen (1988) defines effect sizes of 0.2 as small, 0.5 as medium and 0.8 as large.
*Note. n= number, SD= Standard deviation, t= t-test test statistic, df= degrees of freedom, p=p-value, d= cohens d*

Further exploratory analyses were completed to explore where the effects lie within the memory cognitive domain. Independent t-tests found no significant differences between good and poor sleepers on RAVLT immediate recall (t(9)=1.61,p=0.14; d= 1.07), RAVLT delayed recall (t(9)=1.99,p=0.08; d=1.33) or RAVLT recognition (t(9)=2.17, p=0.06; d= 1.44).

## Discussion

### *Main findings*

The association between self-report of poorer sleep and better overall cognitive functioning and in particular better memory were the opposite to that predicted by Hypothesis 1. No associations were found between sleep efficiency and cognitive domain composite scores which does not confirm Hypothesis 2. The negative association between PSQI and sleep

efficiency scores suggests there was some consistency between the objective and subjective measure when identifying poor or good sleep. However, there were discrepancies between individual self-reports of sleep quality and an objective measure of sleep efficiency when applying cut off values.

The results did not support secondary Hypothesis 1 as sleepiness was not associated with cognitive performance. There is no evidence to support secondary Hypothesis 2 as relationships between individual sub-test scores and poor self-report of sleep quality was associated with better performance, on memory tests (RAVLT immediate and delayed recall) and a test of executive functioning (mSET). Specifically the associations with higher self-reports of poor sleep and RAVLT immediate and delayed recall suggests that self-reporting poor sleepers may be better at learning and recalling information immediately and after a time delay than individuals who report better sleep quality. Finding poor self-reports of sleep being associated with better performance on the mSET suggests that other executive measures may have been underpowered or not sensitive enough to pick up differences in cognitive performance. Better mSET performance in self-reporting poor sleepers suggests that they had better problem solving, creative thinking and planning abilities than individuals who self-reported better sleep. The results generally did not support secondary Hypothesis 3 because objectively measured poorer sleep efficiency, was associated with fewer errors of commission on the SART indicative of better performance but poor sleep efficacy was associated with slower SART reaction times indicative of poor performance, finding some supporting evidence for secondary Hypothesis 3. The discrepancy between SART errors of commission and reaction times for poorer sleep efficiency should be interpreted with caution due to the small sample size. Although lower sleep efficiency was associated with fewer errors of commission this could simply mean that the person made a larger number of errors of omission and did not attend to any of the information presented, therefore by default reducing the errors of commission.

Exploratory Hypothesis 1 is not supported as analysis on participants with consistent self-report of sleep quality and Actigraphy, defined as good or poor sleepers accordingly, showed poor sleepers performed significantly better on the memory cognitive domain than good sleepers. This result is consistent with correlational analyses suggesting poor sleepers have better memory performance than good sleepers. An analysis of performance on the individual memory tests that comprised the memory domain revealed no significant differences between poor and good sleepers on the individual tests however, all tests had large effect sizes, suggesting individually the tests were underpowered but this is not the case when combined to give a composite domain score.

*Previous research*

Previous reviews of studies examining the effects of sleep and cognition in non-head injured adults have not agreed about how sleep affects memory performance. Shekleton et al. (2010) concluded that memory is not impaired in individuals who have primary insomnia, however, Fortier-Brochu et al. (2012) concluded that insomniacs have small to moderate memory impairments, whereas Waters & Bucks (2011) concluded that sleep loss has some negative effect on short term memory. The present study's results do not support any of the conclusions made in the aforementioned reviews. In general, disagreements between the relationship sleep has with memory performance may be explained by studies using participants with a range of sleep difficulties that have different effects on memory. The techniques used to measure sleep in the present study may have failed to identify specific sleep disorders. It is also possible, the use of different memory tests that are not sensitive to the effects of sleep produce inconsistent findings (Killgore, 2010). No study investigating sleep and memory in non-head injured adults has however, found that poor sleep is associated with better memory suggesting that the relationship between self-reports of sleep problems and memory may be unique in adults with ABI compared to non-injured adults. The difference in memory performance between adults with ABI and non-injured adults may

be explained by the organic cognitive deficits individuals with ABI have as a result of their injury.

Clinchot et al. (1998) completed a longitudinal study attempting to define and correlate the prevalence and type of sleep problems that arise after ABI and found self-reported sleep difficulties were associated with better memory abilities, a finding that is consistent with the present study. Clinchot et al. explain the self-report sleep better memory relationship as being due to some participants having a better memory for their difficulties and therefore having the ability to report their sleep difficulties more accurately.

An alternative explanation for the poor self-report sleep better memory phenomenon after ABI is that self-reporting poor sleepers have more insight into their sleep difficulties as they perform better on higher order executive tests (Mahmood et al., 2004). The present study found evidence to support Mahmood et al.'s findings as self-reports of poor sleep were associated with better performance on the mSET, a test that relies on problem solving, creative thinking and planning, higher order skills linked to insight. Nilsson et al. (2005) found that healthy non-injured, sleep deprived adults perform worse on the mSET compared to healthy controls. The contrasting findings between non-injured adults may be explained by individuals with ABI having organic cognitive deficits. Another possible explanation may be due to participants in Nilsson et al. being artificially sleep deprived rather than having sleep difficulties. The mechanisms associated with artificial sleep deprivation may have different effects on cognition. The present study has found evidence to support both Mahmood et al. and Clinchot et al. suggesting that both memory and insight may have an important role in the self-report of sleep difficulties. These findings suggest that objective sleep measures such as Actigraphy may be useful when identifying sleep difficulties in an ABI population, in addition to self-report measures.

Forty-five percent of participants in this study had inconsistencies between subjective and objective measures, a finding that has been previously reported in studies examining sleep

in non-injured adults (Erman, 2001) and TBI participants (Ouellet & Morin, 2006). The present study found 67 % of participants with incongruent subjective and objective measures of sleep under report poor sleep and 33% over report poor sleep when compared to Actigraphy results, not supporting findings that individuals who have sustained a severe to extremely severe ABI may generally under report sleep difficulties (Elovic et al., 2005). The present study did not identify a clear trend in how individuals with ABIs report their sleep. However, 45% of participants in the sample had difficulty self-reporting their sleep difficulties verified by Actigraphy.

Participants with congruent PSQI and sleep efficiency scores were defined as good and poor sleepers. The sleep difficulties described as good and poor in this study are similar to the sleep difficulties described as good and poor in Bloomfield et al. (2010) where the effects of sleep difficulties on sustained attention were investigated in a HI sample. Good and poor sleepers in the present study had median PSQI scores of 1 and 8 respectively. In Bloomfield et al. good and poor sleepers had median PSQI scores of 2 and 13 respectively. Median sleep efficiency score in the present study was 93.4% for good sleepers and 70.26% for poor sleepers. The median sleep efficiency score in Bloomfield et al. was 96.77% for good sleepers and 77.19% for poor sleepers.

Erdinger et al. (2004) emphasised the importance of using good sleepers rather than just poor sleepers when making group comparisons. Exploratory analysis in the present study of poor sleeper and good sleeper groups, with congruence on subjective and objective sleep measures, indicated that poor sleepers performed better on memory tests than good sleepers, consistent with Clinchot et al. Limited conclusions can be drawn due to the large effect size on the overall cognitive functioning domain and non-significant result suggesting the present study is underpowered and a larger number of participants are needed to find effects.

The present study does not support Bloomfield et al.'s (2010) finding that poor sleepers had poorer sustained attention performance than good sleepers. Bloomfield et al. assessed a community dwelling HI sample whereas the present study assessed individual's receiving inpatient neurorehabiliation. Analysis of individual subtest scores revealed that low sleep efficiency scores, indicative of poor sleep, were associated with a lower number of SART errors of commission; this suggests that poor sleep is associated with better performance, findings contrary to Bloomfield et al. However, low sleep efficiency was associated with slower reaction times, consistent with Bloomfield et al.'s findings. The discrepancy between the two studies may be explained by Bloomfield et al.'s study being higher powered and there being differences in participants' characteristics. It is possible that participants in the present study made more errors of omission by not attending to any of the stimuli and by default making less errors of commission. Further investigation with a larger sample needs to be completed to draw definite conclusions.

At present there are no models linking cognitive functioning and sleep after ABI. In non-brain injured populations a number of neuropsychological models have been proposed to explain the impact of sleep difficulties on cognitive functioning. Killgore et al. (2008) argued that sleep loss affects prefrontal cortex functions resulting in cerebral metabolism changes that impair cognition. However, functional magnetic resonance imaging (fMRI) studies suggest that the prefrontal cortex and other brain areas are activated following sleep deprivation (Chee & Choo, 2004; Tucker et al., 2010). The present study did not find that sleep impaired cognition following ABI. When discussing isolating the effects of pathology and sleep disturbance in relation to neurological patients, Waters and Bucks (2011) suggested that "lesions in brain circuitry and neurotransmitter systems interfere with downstream sleep regulation processes so that the symptoms cannot be teased apart" (p.577). This offers a likely explanation for the present study's findings in that the neuropathological damage that has resulted from ABI may be related to sleep difficulties experienced. Hence, the fact that some participants in the current study showed sleep disturbances that were not directly

correlated with cognitive impairments suggests that these problems may arise from independent brain processes. Another possible mechanism that could explain the relationship between sleep and cognitive impairments are underlying psychological problems, but it was not possible to explore these fully in the present project. It is also possible that sleep could be inter-related to cognitive deficits following ABI, but the present study has not found substantial evidence to support this and accurately explain any mechanism associated.

*Strengths/ limitations*

A strength of this study is that it is the first to explore relationships between sleep and cognitive functioning in an inpatient neurorehabilitation population using subjective and objective measures of sleep. It provides a foundation for others to develop research in this area. Where possible the time of day of cognitive testing was controlled and occurred between 11.00am and 3.00pm reducing the risk of circadian effects on performance.

Discrepancies are identified between subjective and objective measures of sleep. Actigraphy was described as an objective measure of sleep but it has been criticised as being less reliable when distinguishing between still wakefulness and sleep (Sadeh & Acebo, 2002). The sleep measures utilised in this study may have failed to identify and distinguish between specific sleep disorders experienced after ABI that could have different effects on neuropsychological performance. Although the participants were interviewed with the ICSD-II criteria, it is possible that they did not reliably report their current difficulties. It was intended that sleep diaries would be completed by participants and rehabilitation staff to strengthen the validity of the Actigraphy. Unfortunately due to the rehabilitation centres having large staff teams and different shift patterns, diaries were only completed sporadically and were excluded from the analysis. Researchers phoning participants and staff daily may have helped overcome this but could have potentially interrupted the rehabilitation schedule and would not have been practical for the research team. Information was not readily available on the severity of participant's injuries however, due to participants needing

inpatient neurorehabilitation it is likely that all participants sustained a severe to extremely severe ABI.

The study's results should be interpreted with caution as correlational associations do not imply causation and the exploratory, between subjects analysis has a small sample size. It is possible there are significant differences between poor and good sleepers on cognitive domains other than memory but these may not have been found due to the between subjects analyses being underpowered on overall cognition, attention and executive function measures. The cognitive tests used might not detect actual problems in every day cognitive functioning that might be attributable to sleep disturbance therefore, questioning the ecological validity of the measures used.

*Future research*

Future research is necessary to explore sleep disorders further in ABI patients. Techniques in measuring and recording sleep patterns in this population need to be developed to ensure sleep difficulties are characterised appropriately. Future studies using polysomnography (PSG) would help characterise sleep difficulties in this population and remove inaccuracies that result from Actigraphy and self-report of sleep difficulties. These techniques would allow better identification of any relationships between sleep and cognition. Studies using PSG techniques would benefit from a large sample size due to the range of sleep problems that have been found in previous studies.

Conducting a study with a larger sample size may confirm if there are differences between poor and good sleepers on cognitive domains in addition to memory. It may be beneficial to recruit a more homogenous sample in terms of cause of injury. This would make the study more sensitive to injury specific cognitive deficits and increase the clinical utility of the results.

*Clinical Recommendations*

Clinicians should not rely solely on self-report measures when assessing sleep in a severe- to extremely severe ABI in-patient neurorehabilitation population. This study clearly demonstrates there are inconsistencies between subjective and objective measures. Patients with significant memory deficits may be experiencing sleep difficulties but cannot recall experiencing them. Clinicians should be aware patients may benefit from a sleep assessment even when they are not reporting any difficulties as sleep disturbances can be related to problems such as pain, fatigue or irritability (Ouellett & Morin, 2006) that could affect engagement in the rehabilitation process.

## Conclusions

There are discrepancies between objective and subjective measures of sleep in patients who have sustained an ABI and are in-patients in a neurorehabilitation centre. Self-report poor sleep quality is associated with better performance on cognitive tests examining memory. Exploratory analysis suggests poor sleepers defined by both subjective and objective measures have better memory performance than good sleepers. Better memory in poor sleepers may be due to individuals having increased insight into their difficulties and being able to retain and recall problems experienced. Future research with a larger sample and more robust measurements of sleep will allow memory and other cognitive domains to be investigated further in people with an ABI who are undergoing in-patient rehabilitation.

**References**


Altena, E., Van Der Werf, Y.D., Strijers, R.L., & Van Someren, E.J. (2008). Sleep loss affects vigilance: effects of chronic insomnia and sleep therapy. *Journal of Sleep Research 17*, 335–343. http://dx.doi.org/10.1111/j.1365-2869.2008.00671.x

Bloomfield, I., Espie, C., & Evans, J. (2010). Do sleep difficulties exacerbate deficits in sustained attention following traumatic brain injury? *Journal of the international neuropsychological society 16*, 17-25. http://dx.doi.org/10.1017/S1355617709990798

Bjelland, I., Dahl, A. A., Haug, T. T., & Neckelmann, D. (2002). The validity of the Hospital Anxiety and Depression Scale: an updated literature review. *Journal of psychosomatic research*, *52*, 69-77. http://dx.doi.org/10.1016/S0022-3999(01)00296-3

Broughton, R. (1982). Performance and evoked potential measures of various states of daytime sleepiness. *Sleep*, 5 , S135-S146.

Burgess, P. W., & Shallice, T. (1996). Response suppression, initiation and strategy use following frontal lobe lesions. *Neuropsychologia, 34*, 263–272. http://dx.doi.org/10.1016/0028-3932(95)00104-2

Burgess, P., Alderman, N., Forbes, C., et al. (2006) The case for a development and use of "ecologically valid" measures of executive functions in experimental and clinical neuropsychology. *Journal of the international neuropsychological society,* 12 194-209 http://dx.doi.org/10.1017/S1355617706060310

Buysse, D.J., Reynolds, C.F., Monk, T.H., Berman, S.R., & Kupfer, D.J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28* , 193 – 213. http://dx.doi.org/10.1016/0165-1781(89)90047-4

Campos-Morales, R.M., Valencia-Flores, M., Castan˜o-Meneses, A., Castan˜eda-Figueiras, S., & Martı´nez-Guerrero, J. (2005). Sleepiness, performance and mood in a group of Mexican undergraduate students. *Biological Rhythm Research, 26*, 9–13. http://dx.doi.org/10.1080/09291010400028484

Chee, M.W., & Choo, W.C. (2004). Functional imaging of working memory after 24 hr of total sleep deprivation. *Journal of Neuroscience*, 24, 4560–4567. http://dx.doi.org/10.1523/JNEUROSCI.0007-04.2004

Cicerone, K.D., Dahlberg, C., Malec, J., Langenbahn, D., Felicetti, T., et al. (2005). Evidence based Cognitive rehabilitation: updated review of the literature from 1998–2002. *Archives of Physical Medicine Rehabilitation, 86*, 1681–1692. http://dx.doi.org/10.1016/j.apmr.2005.03.024

Clinchot, D. M., Bogner, J., Mysiw, W. J., Fugate, L., & Corrigan, J. (1998). Defining sleep disturbance after brain injury. *American Journal of Physical Medicine & Rehabilitation*, *77*, 291–295. http://dx.doi.org/10.1097/00002060-199807000-00006

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Cohen, M., Oksenberg, A., Snir, D., Stern, M., & Groswasser, Z. (1992). Temporally related changes of sleep complaints in traumatic brain injured patients*. Journal of neurology, neurosurgery, and psychiatry, 55*, 313-315. http://dx.doi.org/10.1136/jnnp.55.4.313

Crawford, J. R., & Garthwaite, P. H. (2002). Investigation of the single case in neuropsychology: Confidence limits on the abnormality of test scores and test score differences. *Neuropsychologia*, *40*, 1196 –1208. http://dx.doi.org/10.1016/S0028-3932(01)00224-X

Crowe, S.F. (2000). Does the letter number sequencing task measure anything more than digit span? *Assessment,* 7, 113-117. http://dx.doi.org/10.1177/107319110000700202

Dawkins, N., Cloherty, M. E., Gracey, F., & Evans, J. J. (2006). The factor structure of the Hospital Anxiety and Depression Scale in acquired brain injury. *Brain injury*, *20*, 1235-1239. http://dx.doi.org/10.1080/02699050601076414

Edinger , J.D., Bonnet, M.H., Bootzin, R.R., Doghramji, K., Dorsey, C.M., Espie, C.A., et al. (2004). Derivation of research diagnostic criteria for insomnia: Report of an American Academy of Sleep Medicine Work Group. *Sleep*, *27*, 1567 – 1596.

Edinger, J.D., Wyatt, J.K., Olsen, M.K., Stechuchak, K.M., Carney, C.E., Chiang ,A., Krystal, A.D., Lineberger, M.D., Means, M.K., Radtke, R.A., Knauss, F. (2009) Reliability and validity of insomnia diagnoses derived from the Duke Structured Interview for Sleep Disorders. *Sleep*.32(suppl):A265.

Elovic, E.P., Dobrovic, N.M., & Fellus, J.L. (2005). Fatigue after traumatic brain injury. In J.DeLuca (Ed.), *Fatigue as a Window to the Brain* Cambridge, MA: Masachusetts Institute of Technology.

Erman, M.K. (2001). Sleep architecture and its relationship to insomnia. *Journal of Clinical Psychiatry*, *62*, 9 – 17.

Eslinger, P., Downey-Lamb, M., Ward, S., Robertson, I., & Glisky, M. (2002). *Neuropsychological interventions: Clinical research & practice*. New York: The Guilford Press.

Fortier-Brochu, E., Beaulieu-Bonneau, S., Ivers, H., & Morin, C. (2012). Insomnia and daytime cognitive performance: A meta-analysis *Sleep Medicine Reviews, 16*, 83-94. http://dx.doi.org/10.1016/j.smrv.2011.03.008

Fictenberg, N. L., Putnam, S. H., Mann, N. R., Zafonte, R. D., & Millard, A. E. (2001). Insomnia screening in postacute traumatic brain injury: utility and validity of the Pittsburgh Sleep Quality Index. *American Journal of Physical Medicine and Rehabilitation*, *80*, 339–345. http://dx.doi.org/10.1097/00002060-200105000-00003

Gradisar, M., Terrill, G., Johnston, A., & Douglas, P. (2008). Adolescent sleep and working memory performance. *Sleep and Biological Rhythms, 6*, 146–154. http://dx.doi.org/10.1111/j.1479-8425.2008.00353.x

Harrison, Y., & Horne, J.A. (1997). Sleep deprivation affects speech. *Sleep, 20*, 871–877.

Harrison, Y., & Horne, J.A. (1998). Sleep loss impairs short and novel language tasks having a prefrontal focus*. Journal of Sleep Research*, *7*, 95–100. http://dx.doi.org/10.1046/j.1365-2869.1998.00104.x

Hoddes, E., Dement, W.E., & Zarcone, V. (1972). The history and use of the Stanford Sleepiness Scale. *Psychophysiology, 9,* 150.

Hoddes, E., Zarcone, V., Smythe, H., Phillips, R., & Dement, W.C. (1973). Quantification of sleepiness: a new approach. *Psychophysiology*, 10, 431–436. http://dx.doi.org/10.1111/j.1469-8986.1973.tb00801.x

International Classification of Sleep Disorders II (ICSD-II; 2005). Diagnostic and Coding Manual, 2nd ed. Westchester: American Academy of Sleep Medicine

Killgore, W.D., Kahn-Greene, E.T., Lipizzi, E.L., Newman, R.A., Kamimori, G.H., & Balkin, T.J. (2008). Sleep deprivation reduces perceived emotional intelligence and constructive thinking skills. *Sleep Medicine*, 9, 517–526. http://dx.doi.org/10.1016/j.sleep.2007.07.003

Killgore, W.D. (2010). Effects of sleep deprivation on cognition. *Progress in Brain Research 185*, 105-129. http://dx.doi.org/10.1016/B978-0-444-53702-7.00007-5

Lezak, M.D., Howieson, D.B., & Loring, D.W. (2004*). Neuropsychological Assessment* (4th ed.). New York: Oxford University Press.

McLean A, Dikman S, Temkin N, (1993). Psychosocial recovery after head injury, *Archives of Physical Medicine Rehabilitation,* 74: 1041-1046. http://dx.doi.org/10.1016/0003-9993(93)90059-J

McLellan, D.L. (1991) Functional recovery and the principles of disability medicine. In Swash. M., Oxbury, J. (Eds).,*Clinical Neurology*,. Edinburgh, UK: Churchill Livingstone

Mahmood, O., Rapport, L.J., Hanks, R.A., & Fichtenberg, N.L. (2004). Neuropsychological performance and sleep disturbance following traumatic brain injury. *Journal of Head Trauma Rehabilitation, 19,* 378–390. http://dx.doi.org/10.1097/00001199-200409000-00003

Makley, M. J., English, J. B., Drubach, D.A., Kreuz, A. J., Celnik, P.A., & Tarwater, P.M. (2008) Prevalence of sleep disturbance in closed head injury patients in a rehabilitation unit. *Neurorehabilitation and Neural Repair*, 22, 341-347. http://dx.doi.org/10.1177/1545968308315598

Morfiri, E. (2013) Prevalence and correlates of sleep problems in head injury patients in rehabilitation. DClinPsy Thesis. *The University of Glasgow*, Scotland.

Nilsson, J.P., Soderstrom, M., Karlsson, A.U., Lekander, M., Akerstedt, T., Lindroth, N.E., & Axelsson, J. (2005). Less effective executive functioning after one night's sleep deprivation. *Journal of Sleep Research, 14*, 1–6. http://dx.doi.org/10.1111/j.1365-2869.2005.00442.x

Orff, H.J., Ayalon, L., & Drummond, S.P. (2009). Traumatic brain injury and sleep disturbance: a review of current research. *Journal of Head Trauma Rehabilitation,* 24, 155–165. http://dx.doi.org/10.1097/HTR.0b013e3181a0b281

Ouellet, M.C., & Morin , C.M. (2004). Cognitive Behaviour Therapy for Insomnia Associated with Traumatic Brain Injury: A Single Case Study. Archives of Physical Medicine Rehabilitation, 85, 1298-1302. http://dx.doi.org/10.1016/j.apmr.2003.11.036

Ouellet, M.C., & Morin , C.M. (2006). Subjective and objective measures of insomnia in the context of traumatic brain injury: A preliminary study. *Sleep Medicine*,*7*, 486 – 497. http://dx.doi.org/10.1016/j.sleep.2006.03.017

Ouellet, M.C., & Beaulieu-Bonneau, S. (2009). *Sleep disorders in rehabilitation patients.* In: J.H. Stone & M. Blouin (Eds.) International Encyclopaedia of Rehabilitation. Available online: http://cirrie.buffalo.edu/encyclopedia/article.php?id=43&language=en

Powell, J.B., Cripe, L.I., & Dodrill, C.B. (1991). Assessment of brain impairment with the Rey Auditory Verbal Learning Test: A comparison with other neuropsychological measures. *Archives of Clinical Neuropsychology,* 6, 241-249

Rey, A. (1941). L'examen psychologique dans les cas d'ence´phalopathie traumatique. *Archives de Psychologie*, 28, 21.

Robertson, I.H., Manly, T., Andrade, J., Baddeley, B.T., & Yiend, J. (1997). 'Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects . *Neuropsychologia 35* , 747 – 758. http://dx.doi.org/10.1016/S0028-3932(97)00015-8

Ross,T.P., Furr, A.E., Carter,S.E., & Weinberg, M. (2006) The psychometric equivalence of two alternate forms of the Controlled Oral Word Association Test. *The Clinical Neuropsychologist*, 20, 414-617. http://dx.doi.org/10.1080/13854040590967153

Sadeh, A. & Acebo, C. (2002). The role of actigraphy in sleep medicine. *Sleep Medicine Reviews*,*6*, 113 – 124 . http://dx.doi.org/10.1053/smrv.2001.0182

Scottish Needs Assessment Programme (2000). *Huntington's Disease, acquired brain injury and early onset dementia*. Glasgow: Office for Public Health in Scotland.

Scottish Intercollegiate Guidelines Network (SIGN,130) (2013). *Brain injury rehabilitation in adults.* Edinburgh: SIGN

Sinclair, K.L., Ponsford, J.L., Rajaratnam, S.M., & Anderson, C., (2013). Sustained attention following traumatic brain injury: use of the Psychomotor Vigilance Task. Journal of Clinical Experimental Neuropsychology, *35,* 210-224. http://dx.doi.org/10.1080/13803395.2012.762340

Souza, D.L., Benedito-Silva, A.A., Pires, M.L.N., Poyares. D., et al. (2003). Further Validation of Actigraphy for Sleep Studies, *Sleep,* 26, 81-85

Shekleton, J.A., Rogers, N.L., & Rajartnam, M.W. (2010). Searching for the day time impairments of daytime insomnia *Sleep Medicine Reviews 14*, 47-60. http://dx.doi.org/10.1016/j.smrv.2009.06.001

Tucker, A.M., Whitney, P., Belenky, G., Hinson, J.M., & Van Dongen, H.P. (2010). Effects of sleep deprivation on dissociated components of executive functioning. *Sleep*, 33, 47–57.

Waters, F. & Bucks,R.S. (2011). Neuropsychological Effects of Sleep Loss: Implication for Neuropsychologists *Journal of the International Neuropsychological Society* 17, 571–586. http://dx.doi.org/10.1017/S1355617711000610

Wilson, B.A., Alderman, N., Burguess, P.W., et al. (1996). *Manual of the behavioural assessment of the dysexecutive syndrome.* Bury St Edmunds U.K.: Thames Valley Test Company.

Wilson, B.A. (2008). Neuropsychological Rehabilitation *Annual Review of Clinical Psychology* 4, 141-162. http://dx.doi.org/10.1146/annurev.clinpsy.4.022007.141212

Wechsler (2008). *WAIS-IV administration and scoring manual*. San Antonio, TX: Pearson .

Whitnall, L., McMillan, T.M., Murray, G., et al. (2006). Disability in young people with headinjury: a 5-7 year follow-up of a prospective cohort study. *Journal of Neurology Neurosurgery Psychiatry*; 77, 640- 645. http://dx.doi.org/10.1136/jnnp.2005.078246

Zigmond, A.S., & Snaith, R.P. (1983). The hospital anxiety and depression scale . *Acta Psychiatrica Scandinavica*, *67* , 361 – 370. http://dx.doi.org/10.1111/j.1600-0447.1983.tb09716.x

# CHAPTER 3: ADVANCED CLINICAL PRACTICE I

## REFLECTIVE ACCOUNT

## *Neuropsychological Assessment – A statistical exercise?*

Allan Stuart Thomson

***Submitted in partial fulfilment of the requirements for the degree of***

***Doctorate in Clinical Psychology (DClinPsy)***

Address for correspondence:

Allan Stuart Thomson

Academic Unit of Mental Health and Wellbeing

University of Glasgow

Gartnavel Royal Hospital

1055 Great Western Road

Glasgow, G12 0XH

Email: allan.thomson1@nhs.net

## ABSTRACT

Neuropsychological assessment is a complex process that presents a number of ethical questions. In this account, the process of neuropsychological assessment has been split into four stages: (i) Purpose of assessment; (ii) Consent and confidentiality; (iii) Test selection and administration and (iv) Results analysis. Arising ethical issues arising and professional responsibilities have been reflected on at each of the four stages. Each stage is understood in the context of Gibbs' (1988) reflective cycle. I consider how my view of the process has developed from an Assistant Psychologist to nearing qualification. I conclude by discussing the learning points in relation to the British Psychological Society (BPS, 2009) Code of Conduct and Ethics principals.

# CHAPTER 4: ADVANCED CLINICAL PRACTICE II

## REFLECTIVE ACCOUNT

## *Is Teaching and Training Psychological Concepts a Collaborative Process?*

Allan Stuart Thomson

***Submitted in partial fulfilment of the requirements for the degree of***

***Doctorate in Clinical Psychology (DClinPsy)***

Address for correspondence:

Allan Stuart Thomson

Academic Unit of Mental Health and Wellbeing

University of Glasgow

Gartnavel Royal Hospital

1055 Great Western Road

Glasgow, G12 0XH

Email: allan.thomson1@nhs.net

## ABSTRACT

The Health and Care Professionals Council's (HCPC, 2009) Standards of Proficiency document states that Clinical Psychologists need to be competent in training others. In this reflective account, reflections have been made using Gibbs' (1988) reflective cycle at three stages when I designed and implemented a training session, whilst completing a Forensic Learning Disabilities placement. Reflections are made on preparation, session content and presentation/delivery. My reflections are reviewed in relation to the HCPC Standards of Proficiency. The account aims to capture the development of my competencies over time using Gibbs' reflective cycle, but further reflections were made using Stoltenbergs (1981) Integrative Developmental Model, to fully illustrate my development over time. Comparisons are made between teaching/ training and clinical therapeutic interactions.

## Appendix 1.1: Levels of Evidence (Study Class) used by Cicerone et al. (2000)

| Level of Evidence | Study Requirements |
|---|---|
| Class I | Well designed, prospective randomised controlled trials |
| Class 1A | Prospective design with "quasi-randomised" assignment of treatment conditions, such as prospective assignment of subjects to alternating conditions |
| Class II | Prospective, nonrandomized cohort studies; retrospective, nonrandomized case-control studies; or clinical series with well-designed controls that permitted between subject comparisons of treatment conditions, such as multiple baseline across subjects |
| Class III | Clinical series without concurrent controls, or studies with results from 1 or more single cases that used appropriate single-subject methods, such as multiple baseline across interventions with adequate quantification and analysis of results |

**Appendix 1.2: Methodological Quality Rating Checklist. PEDro-P**

| PEDro-P Scale | Aben et al (2013) | Shum et al (2011) | Potvin et al (2011) | O'neil-pirozzi et al (2010) | Stringer (2011) | Bergquist et al (2009) | Dowds et al (2011) | Chen et al (2012) |
|---|---|---|---|---|---|---|---|---|
| 1. Eligibility criteria were specified | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 2. Subjects were randomly allocated to interventions (in a crossover study, subjects were randomly allocated an order in which treatments were received) | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| 3. Allocation was concealed | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| 4. the intervention groups were similar at baseline regarding the most important prognostic indicators | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| 5. There was blinding of all subjects | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 6. There was blinding of all therapists who administered the therapy | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7. There was blinding of all assessors who measured at least one key outcome | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| 9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat" | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 10. The results of between- intervention group statistical comparisons are reported for at least one key outcome | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11. The study provides both point measures and measures of variability for at least one key outcome | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| **TOTAL /10** | 9 | 7 | 4 | 3 | 3 | 5 | 4 | 6 |

## Appendix 1.3 Definitions of Levels of Recommendations from Cicerone et al. 2011

| Standard | Level of Recommendation |
|---|---|
| *Practice Standard* | Based on at least 1, well-designed class I study with an adequate sample, with support from class II or class III evidence that directly addresses the effectiveness of the treatment in question providing substantive evidence of effectiveness to support a recommendation that the treatment be specifically considered for people with acquired neurocognitive impairments and disability. |
| *Practice Guideline* | Practice guidelines based on 1 or more class I studies with methodological limitations, or well-designed class II studies with adequate samples that directly address the effectiveness of the treatment in question, providing evidence of probable effectiveness to support a recommendation that the treatment be specifically considered for people with acquired neurocognitive impairments and disability. |
| *Practice Option* | Based on class II or class III studies that directly address the effectiveness of the treatment in question, providing evidence of possible effectiveness to support a recommendation that the treatment be specifically considered for people with acquired neurocognitive impairments and disability. |

## Appendix 1.4: Guidelines for submission to Neuropsychological Rehabilitation

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**Appendix 2.1 Major Research Project Proposal**

# Major Research Project Proposal

## Do sleep difficulties exacerbate cognitive deficits following Head Injury in an inpatient rehabilitation population?


**Allan Stuart Thomson**

**Version 1.4**

## Abstract

### Background

Problems with memory, attention, executive functioning and speed of processing are the most typical cognitive difficulties faced by those who have sustained a head injury (Wilson, 2008). However, sleep difficulties also reliably produce reductions in speed of processing and attention tasks, with memory and executive functions also affected to a lesser extent by sleep loss (Waters and Bucks, 2010). Insomnia also impacts on cognitive function. Sleep disturbance in head injury samples is reported to range from 27% to 72.7% (Maclean et al., 1993; Makley et al., 2008; Cohen et al., 1992) and can prolong the duration of inpatient stay (Makley et al., 2008).

### Aims

This study will explore the relationship between sleep and cognitive deficits in participants who have sustained a head injury and who are undergoing inpatient rehabilitation. Based on their sleep, participants will be characterised as good or poor sleepers. The study will explore any potential differences in cognitive performance between poor and sleepers on sustained attention, executive function and memory tasks, the domains which are noted to have the largest deficits in the head injured inpatient population.

### Method

Participants will be recruited from rehabilitation centres and categorised as good and poor sleepers. Participants will then be screened using a number of neuropsychological tests examining sustained attention, executive functions and memory.

### Applications

If a relationship between sleep difficulties and cognitive functioning in inpatients who have a head injury is demonstrated, this study could be a foundation for future research exploring how sleep intervention could help rehabilitate cognitive deficits that are exacerbated by sleep difficulties.

## Introduction

Head injury can refer generally to injury involving the brain and in some cases it can refer to injury of other head structures such as the face or jaw (Lezak et al., 2004). In the literature the terms head injury and traumatic brain injury (TBI) are used interchangeably; however TBI can sometimes be used as a broad term that encompasses a range of aetiologies such as stroke and anoxia. For the purposes of this study, the term head injury will be used to distinguish an injury to the brain caused by trauma to the head. In European countries, there are approximately 150-300 head injuries per 100,000 population annually (Tagliaferri et al., 2006). In Southern Europe, the leading cause of head injuries are road traffic crashes and in Northern Europe, falls mainly related to alcohol consumption (Hukkelhoven et al., 2002). Head injuries are associated with a range of physical, cognitive, emotional and social problems.

After an individual sustains a head injury, they will often need to participate in rehabilitation, where they will engage in a two way interactive process with professional staff, relatives and members of the wider community to achieve their optimum physical, psychological, social and vocational well-being (McLellan, 1991). When head injuries are severe and a range of difficulties are experienced, individuals will often engage in inpatient rehabilitation.

Unless a head injury is very mild, cognitive deficits are generally observed in individuals who have experienced trauma to the brain. Problems with memory, attention, executive functioning and speed of processing are the most typical difficulties faced by those who have sustained a head injury (Wilson, 2008). Cicerone et al. (2005) concluded that there is a substantial evidence base demonstrating that patients with head injury benefit from cognitive rehabilitation. They propose that further research should move on from investigating whether cognitive rehabilitation is effective and examine patient characteristics that optimise outcomes of cognitive rehabilitation.

The evidence base demonstrating a close relationship between sleep loss and cognition is growing (Waters & Bucks, 2010). The same authors highlighted that sleep loss and cognition reliably produces reductions in speed of processing and attention tasks. Higher order cognitive functions such as memory and executive functions are also affected to a lesser extent by sleep loss. Crystallised abilities such as language tasks appear to remain preserved after sleep loss.

Shekleton et al. (2009) reviewed studies to investigate which cognitive domains appear to be most consistently impaired in subjects with primary insomnia. The review highlights that

studies have produced inconsistent and sometimes conflicting findings. Consistent with sleep deprivation studies attention tasks and working memory tasks appear to show deficits in participants with insomnia. A meta-analysis was completed by Fortier-Brochu et al. (2010) to provide a quantitative summary of the magnitude of differences on neuropsychological test performance between participants with primary insomnia and normal sleepers. Significant impairments of a small to moderate size were found on tasks assessing episodic memory, problem solving, manipulation in working memory and retention in working memory. No significant group differences were observed in tasks assessing general cognitive function, perceptual and psychomotor processes, procedural learning, verbal functions, different dimensions of attention and some aspects of executive functioning. The results of the meta-analysis provide inconsistent findings with Shekleton et al's review. Methodological variations and different definitions of insomnia are likely to have contributed to inconsistencies. Killgore (2010) explains that some of the tests used are well suited to detect severe levels of brain damage, but may not demonstrate adequate sensitivity for detecting deficits and instability of performance that may accompany sleep loss.

Sustained attention or vigilance refers to the capacity to maintain an attentional activity over a period of time (Lezak et al., 2004). It is almost impossible to engage in complex cognitive processes without some degree of sustained attention (Killgore, 2010). Alertness and sustained attention also appear to be the cognitive capacities most consistently effected by sleep loss (Lim & Dinges, 2008, 2010). The Psychomotor Vigilance Test (PVT; Dinges & Powell, 1985) is a commonly used test to assess alertness and sustained attention. Participants press a button in response to a white light appearing at random time intervals. When the light appears red participants must not press the button. The PVT is described as the "gold standard" for assessment of the effects of sleep deprivation on cognition because it is highly reliable, sensitive to prolonged wakefulness and circadian influences, and shows very little effect of learning (Dinges et al., 1997; Van Dongen et al., 2003). Bloomfield et al. (2010) found that poor sleepers post TBI had significantly poorer sustained attention abilities than good sleepers post TBI using the Sustained Attention to Response Test (SART).

Executive functions consist of those capacities that enable a person to engage successfully in independent purposive, self-serving behaviour (Lezak et al. 2004). Harrison and Horne (1998, 2000) and Horne (1993) propose a model where sleep loss specifically impacts on executive function. As a result research has tested a number of domains of executive functioning to test this proposal. Waters & Bucks' (2010) review illustrates a range of studies examining mental flexibility and switching, divided attention, working memory, inhibition, verbal fluency and problem solving, creative thinking, all the major domains of executive

functioning, to have found significant impairments due to sleep loss. Fortier-Brochu et al.'s (2011) meta-analysis highlighted that research studies found there can be significant impairments in people with insomnia in a number of executive functions (problem solving, manipulation in working memory and retention in working memory), whereas in other executive functions (verbal fluency and cognitive flexibility) they found no effect.

Working memory refers to the online storage, monitoring and manipulation of information (Baddeley, 1986). Working memory deficits are commonly found in individuals who have sustained a head injury (McDowell et al. 1997). Gradisar et al. (2008) found significant differences in task performance between adolescence who slept for less than 8 hours and those who slept for 8-9 hours. Significant group differences on tasks of working memory have been found when comparing patients with insomnia with healthy controls. (Bonnet & Arand, 1995; Varkeviser & Kerkhof, 2005; Vignola et al., 2000) A range of cognitive tests can be used to assess working memory. Bonnet & Arand (1995), Varkeviser & Kerkhof (2005) and Vignola et al. (2000) used a memory and search task, the two back memory task and digit span backwards respectively to demonstrate that working memory is poorer in insomniacs compared to controls. A body of research has however found that there is no difference on performance on more complex tasks of working memory when comparing poor and normal sleepers. Turner et al. (2007) propose that this is due to simple tasks examining working memory having a greater impact on attention than working memory.

Verbal fluency is a measure of an individual's ability to generate responses from a given category or cue. Poor performance on verbal fluency tests is commonly associated with head injury. Verbal fluency tests can be used as an index of frontal lobe function (Benton, 1968). Poor performance on verbal fluency tasks is common after sleep loss. Studies have reported fewer words recalled and perseveration when participants are sleep deprived (Harrison & Horne, 1997, 1998; Horne 1988). Harrison and Horne (1997) reported that after sleep deprivation the number of words recalled by participants who were sleep deprived decreased by about 6 words compared to the non-sleep deprived group where slight increases in the number of words were observed. Shekleton et al. (2009) and Fortier-Brochu et al.'s (2011) review papers found there to be notable impairments of verbal fluency in individuals with insomnia.

Problem solving is when individuals use cognitive skills to find solutions to problems using more than the information given (Bruner, Goodnow & Austin, 1956). Sleep deprivation studies have found evidence of deficits in problem solving. Nilsson et al. (2005) found a sleep deprived group were significantly impaired on the modified six elements test (mSET)

performance compared to a control group. They observed rule breaking and deficits in monitoring and planning in the sleep deprived group. Fang et al. (2008) report deficits in problem solving on the Wisconsin card sort task when comparing insomniacs to healthy controls.

Inhibitory control is the ability to suppress, interrupt, or delay an activated behaviour or cognitive course of interaction (Aron et al., 2004). Harrison & Horne (1998) found that a sleep deprivation group were significantly impaired on the hayling test compared to a control nil sleep deprivation group. Errors were made in part two of the test where the sleep deprived group made more errors when asked to provide incongruent endings to sentences. The sleep deprived group also had longer response latencies compared to the control group.

Memory is the process in which information is encoded, stored and retrieved. Campos-Morales et al. (2005) compared participants who rated themselves as sleepy and participants who were not sleepys' recall and learning on the Rey Auditory Memory Test . Sleepy participants did not learn and recall as many words as non-sleepy participants suggesting sleepiness can cause deficits in recall and learning. Sheckleton et al. (2010) report that most studies have not observed deficits in new verbal learning in individuals with insomnia. However, they acknowledge Bonnet & Arand (1995) reported that insomniacs recalled significantly fewer words on a recall trial.

Sleep disturbance in head injury populations is reported to range from 27% to 72.7% (Maclean et al, 1993; Makley et al., 2008; Cohen et al 1992). Ouellet et al., (2006) emphasise sleep difficulties in those who have sustained a TBI can "exacerbate pain, cognitive deficits, fatigue or irritability" suggesting sleep difficulties could slow the recovery process after head injury. Sleep difficulties in the head injury population are often under reported by healthcare professionals as other sequelae associated with head injury is classed as more pertinent in the rehabilitation process. Makley et al. (2008) carried out a study to determine the prevalence of sleep wake cycle disturbance of head injury patients in an inpatient rehabilitation facility. Interestingly, they found that patients who had sleep disturbance stayed longer in rehabilitation centres when matched with patients who had as severe injuries and had not sleep difficulties.

The literature highlights that sleep and cognitive deficits are related. The most common impairments observed in head injured patients in rehabilitation centres and impairments as a result of sleep are similar; memory, attention, executive functioning and speed of processing. It is possible that sleep difficulties may exacerbate some of the neuropsychological impairments observed in this population. Investigating this Hypothesis will start to examine

Cicerone et al.'s recommendation of examining the patient characteristics that influence cognitive rehabilitation. If sleep is found to exacerbate cognitive deficits cognitive behaviour interventions (Oullet et al., 2007), that have been found to be effective in the injury population, and other behavioural sleep medicine techniques may be appropriate strategies to help rehabilitation by either helping to improve cognitive performance or shorten in-patient stays (Makley et al., 2008)

**Aims and Hypothesis**

This study aims to explore the relationship between sleep and cognitive deficits in participants who have sustained a head injury who are in an inpatient rehabilitation facility. The study aims to categorise participants into good and poor sleep groups and explore if there are differences in cognitive performance across sustained attention, executive functions and memory, the domains which are noted to have the largest deficits in the head injured inpatient population.

Hypotheses –

- Poor sleepers will make more errors of commission and have faster average reaction times than the good sleep group on the SART
- Poor sleepers will score worse on the letter number sequencing tasks than good sleepers.
- Poor sleeper will generate fewer words on a test of verbal fluency than good sleepers.
- Poor sleepers will have lower total scores on the modified six elements test (mSET) than good sleepers.
- Poor sleepers will make more errors when providing an incongruous ending to sentences in the sentences in part 2 of the Hayling test compared to good sleepers
- Poor sleepers will have larger response latencies than good sleepers in part 2 of the Hayling test.
- Poor sleepers will recall fewer words on immediate recall, distractor tasks and recognition tasks than good sleepers.

**Plan of Investigation**

*Participants*

Participants will be recruited from two rehabilitation centres- The Brain Injury Rehabilitation Trust, Graham Anderson House and the brain injury rehabilitation centre, Huntercombe Services Murdostoun.

*Inclusion criteria*

Participants who will be included will be 18-64 years old who have sustained a head injury. Participants will have been a patient in the rehabilitation centre for at least 3 weeks and have settled into the rehabilitation schedule. Participants will be included up to 1 year since injury. Participants will or will not have a sleep difficulty.

*Exclusion criteria*

Those fitting criteria for a sleep disorder such as sleep apnoea, narcolepsy, restless legs or periodic limb movement disorder will be excluded because the mechanisms associated with these disorders will impact on cognition in a different way to the sleep problems included. Potential participants with severe psychiatric symptoms and/or on going substance misuse would also be excluded. Also, other neurological conditions or acquired brain injury. If any impairments of language, perception or general intellect are identified and in the judgement of the clinical team or researcher will make the tests or interview invalid they will also be excluded.

*Recruitment Procedures*

Rehabilitation centre staff will be informed of the details of the study. Staff will identify participants who they believe meet the inclusion criteria and will obtain verbal consent for the researchers to discuss the study with them. Potential participants will then be provided with information about the study. If the participant then expresses interest in participation they will be asked to complete a consent form.

Participants may also be recruited when their participation in another research study that is also being undertaken in the facility is coming to an end. Participants will have been asked by a member of the clinical team when they were approached about the first study if they would like to receive information about this study when the first study ends. When their involvement in that study is coming to an end participants whom the researcher feels meets the research criteria, will be asked if they would like to participate in this study. If the

potential participant is interested they will be provided with information about the study. If the participant then expresses interest in participation they will be asked to complete a consent form. No participant will be enrolled in two studies at one time and after they are informed about the possibility of taking part in a second study they will not be approached with information until 48 hours after they have completed participating in the initial study they were enrolled.

If the participant then expresses interest in participation they will be asked to complete a consent form. Following consent, screening measures will be completed to determine if they are good or poor sleepers and to confirm their suitability for the study. Poor sleepers will be defined as having significant results on at least two of the following; Identification of insomnia or a circadian rhythm disorder defined by a semi structured interview based on the International Classification of Sleep Disorders (ICSD-II, American Academy of Sleep Medicine, 2005), a score of 6 or more on the Pittsburgh Sleep Quality Index (PSQI), score of 14 or more on the Insomnia Severity Index, reports of poor sleep on sleep diaries and the following actigraphy parameter at least three times during a  week period, total sleep time(TST) of less than 6.5 hours, a sleep efficiency (SE) score of less than 85%, or a sleep onset latency (SOL) of greater than 30 minutes. The good sleep group will not have an insomnia or circadian rhythm disorders identified on the ICSD-II, a score of 5 or less on the PSQI, a score of less than 7 on the ISI, no reports of poor sleep on sleep diaries and  a do not meet any of the actigraphy criteria outlined above.

*Measures*

*Background Measures of mood and cognition*

- The Hospital Anxiety and Depression Scale (HADS; (HADS; Zigmond and Snaith, 1983) *Administration time- 5 min*
- Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) *Administration time- 5 min*
- Wechsler Abbreviated Scale of Intelligence (WASI, Wechsler, 1999) *Administration time- 20 min*

*Measure of severity of Head Injury*

- Glasgow coma Scale Score(GCS; Teasdale and Jennett, 1974)

Assessed from rehabilitation centre records

- Duration of loss of consciousness (LOC)

Assessed from rehabilitation centre records and participant self-report

- Duration of post traumatic amnesia (PTA)

Assessed from rehabilitation centre record and participant self-report

*Sleep Measures*

- Semi Structured Clinical Interview

A semi structured interview based on the International Classification of Sleep Disorders (ICSD-II) will be conducted to classify sleep difficulties. *Administration time- 20 min*

- The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989 )

The PSQI is a global measure of sleep quality. A cut off score of five or greater has been validated to differentiate between those with and without sleep disturbance in head injury patients (Mahmood et al 2004). *Administration time- 5 min*

- Insomnia Severity Index (ISI; Morin, 1993)

The ISI is a self-report measure of subjective symptoms of insomnia and also quantifies scores into the following four categories: 0–7 = No clinically significant insomnia, 8–14 = Sub threshold insomnia, 15–21 = Clinical insomnia (moderate severity), 22–28 = Clinical insomnia (severe) *Administration time- 5 min*

- Sleep diary

Sleep diaries will provide a prospective measure of subjective sleep parameters. Diaries will be completed by participants for 7 days. In the cases that patients are not able to record their sleep wake patterns staff will be asked to keep the sleep diaries.

- Actigraphy

Actigraphy will be used as an objective measure of sleep. Sadeh and Acebo (2002) have shown that actigraphy is a satisfactory objective estimate of sleep particularly in terms of global sleep parameters such as total sleep time (TST), sleep onset latency (SOL) and sleep efficiency (SE). Actiwatches will be worn for 7 days

- Stanford Sleepiness Scale (SSS; (Hoddes et al., 1972)

A measure of sleepiness at the time of assessment. *Administration time- 5 min*

***Measures of cognitive function***

*Sustained Attention*

- The Sustained Attention to Response Test (SART; Robertson et al., 1997)

The SART is a measure of sustained attention. Participants are presented with single digits (1-9) in a quasi-random sequence on a computer screen. Participants have to respond to digits with a key press with the exception of the number 3 where they have to withhold a response. Performance is measured by recording error of commission's and the average reaction times. *Administration time- 10 min*

- Psychomotor Vigilance Test (PVT)

Participants press a button in response to a white light appearing at random time intervals. When the light appears red participants must not press the button. Performance is measured by recording how many times the button is not pressed with the light changes colour. *Administration time- 10 min*

*Executive Functions*

Executive functions have not been investigated in a head injury population who are experiencing sleep difficulties. Studies examining executive functions and sleep in the general population were consulted to direct test selection.

- Letter number sequencing *(working memory)*

Letter number sequencing involves participants temporarily storing and performing cognitive operations on information. Participants are given a number of jumbled up letters and numbers e.g. (A 2 B 5). Participants are then asked to order letter alphabetically and numbers in numerical order e.g. ( A B 2 5). Performance will be measured by recording the number of correct responses. *Administration time- 5 min*

- FAS (*Verbal fluency)*

Participants are asked to produce as many words as they can within 1 minute when provided with a letter. Participants are provided with the letters F, A and S. The number of words recalled for each letter will be added together to record performance. The number of perseveration errors will also be total and compared between the two groups. *Administration time- 5 min*

- Modified six elements test (mSET) (*problem solving , creative thinking and planning)*

The mSET is a measure of supervisory control of executive functioning and everyday functioning. Participants are asked to complete 3 tasks, storytelling, simple arithmetic and object naming. Each task consists of two sub tasks and subjects are instructed to do something for each of the 6 tasks and to follow the rule to not do the two sub task consecutively. The tasks have a maximum score of 6 where all tasks are started and no rules are broken. Points are then deducted when the rules are broken and/ or a subject spends more than 271 seconds on one of the 6 sub tests. The total scores will be recorded to measure performance. *Administration time- 10 min*

- Hayling sentence completion task (*Inhibition; Burgess and Shallice, 1996)*

The Hayling sentence completion task measures the capacity to inhibit strong associations in favour of novel responses. The Hayling test consists of two parts. The first part involves participants being provided with a sentence and being asked to provide a word that gives a congruent ending. In the second task participants are given a sentence and asked to provide an incongruent response. Response times are recorded for both parts. Performance is measured by recording the number of errors in both parts. Response latencies will also be recorded to compare performance. *Administration time- 10 min*

*Memory*

- Rey Auditory and Verbal Learning Test (RAVLT; Rey, 1941)

A 15 word list is read to the participant followed by an immediate recall task. The list is read a further 4 times and after each time read an immediate recall task follows. A distractor list is then presented with a recall trial, followed by a recall trial for the original list. The participants are then presented with a recognition trial from a list of 50 words. Performance is measured from the total number of words recalled from the initial presentation, the number of words recalled following the distractor task, the number of words correctly recalled in the recognition task and the number of false positives in the recognition task. *Administration time- 15 min*

*Design*

A between subjects design will be used. Participants will be allocated to good and poor sleeper groups based on the criteria set above. The groups will be matched as closely as possible by severity of head injury, time since injury, premorbid IQ, age, gender and length of time in rehabilitation. Severity of head injury will be assessed by examining GCS scores,

duration of PTA and duration of LOC. Premorbid IQ will be assessed using the WTAR. A semi –structured interview conducted with the participant, review of the sleep diaries, completion of screening tests (Pittsburgh Sleep Quality Index, Insomnia Severity Index) and review of actigraphy data will be used to allocate participant's into the good sleeper and poor sleeper groups. If a participant meets the screening inclusion criteria they will complete the cognitive tests. The cognitive tests will be completed in a quiet room and the researcher will try to administer the cognitive tests between 11.00 am and 3.00 pm for each participant where possible to account for circadian effects on performance. The sleep and mood measures will take 40 minutes to administer. The cognitive assessment would be 80 minutes. WTAR and WASI scores may be obtained from the rehabilitation centres standard battery of test administered on admission. This needs to be confirmed with each rehabilitation centre. If a participant has completed any of the cognitive tests as part of their regular treatment at the rehabilitation centres a note will be taken to confirm what tests have been completed and the time that has elapsed since they were administered.

*Data Analysis*

Descriptive statistics will be used to describe the data collected.

Inferential statistics will be completed for each of the hypotheses.

- Poor sleepers will make more errors of commission and have faster average reaction times than the good sleep group on the SART
- Poor sleepers will score worse on the letter number sequencing tasks than good sleepers.
- Poor sleeper will generate fewer words on a test of verbal fluency than good sleepers.
- Poor sleepers will make more errors when providing an incongruous ending to sentences in the sentences in part 2 of the Hayling test compared to good sleepers
- Poor sleepers will have larger response latencies than good sleepers in part 2 of the Hayling test.
- Poor sleepers will have lower total scores on the six elements test (SET) than good sleepers.
- Poor sleepers will recall fewer words on immediate recall, distractor tasks and recognition tasks than good sleepers.

For the hypotheses above the following analysis is proposed. The distribution of the data will be confirmed. If the data has a normal distribution an independent samples t-test will be used to compare the corresponding scores for each hypotheses between the poor sleep and good sleep group. If the data is not normally distributed a Mann Whitney test will be used.

*Mood and Sleepiness*

HADS scores and SSS scores will be correlated against all of the cognitive tests to tests if there is any relationship between mood and cognitive performance and sleepiness and cognitive performance.

*Justification of sample size*

Bloomfield et al. (2010) examined 15 good sleepers and 11 poor sleepers who had sustained a head injuries performance on the SART random and found a statistically significant difference between the poor sleeper and good sleepers. The effect size calculated for their participant's scores on the SART random was d= 1.219. If assuming a similar effect size in the present study, taking a significance level of alpha = 0.05 and power= 0.9, the sample size required for the present study is 13 participants per group. The study will aim for a sample size of 15 per group to allow for attrition. E.g. If any participant wishes to drop out, is no longer able to continue participation due to a change in capacity or physical health condition etc.

*Setting and equipment*

Screening and testing will take place at the recruitment sites detailed above. Access to the cognitive tests and sleep measures selected will be confirmed with University of Glasgow supervisors.

**Health and Safety Issues**

*Researcher Safety Issues*

The proposed research participants are associated with impulsive, irrational or unpredictable behaviour, and poor emotional control. The researcher will consult the rehabilitation centre staff to identify any risks before collecting data. Staff will be consulted on each occasion the researcher meets with the individual to confirm there have been no changes to their presentation and risks have developed since the researcher's last visit. The research will be conducted in rehabilitation centres that have established health and safety protocols that will be followed by the researcher during data collection.

*Participant Safety Issues*

Participants will be provided with information detailing the nature of the study. All data collected will be anonymous and held in accordance to NHS and University of Glasgow data management protocols. If the participant becomes distressed during the research the research will stop. All participants have the right to withdraw from participation at any time. A break will be offered midway through the assessment and also if further are requested by the participant.

**Ethical Issues**

The experimenter will need to access clinical information and discuss individuals with the clinical teams at each recruitment centre. Consent will be sought from the individuals participating in the study. Information will be provided on the procedure and purpose of the research. Participants will be the given opportunity to receive a summary of the findings from this study.

Patients who have sustained head injuries commonly have cognitive deficits. The experimenters will need to ensure participants have the capacity to consent to the study and have the ability to complete the neuropsychological measures. If the experimenter or the rehabilitation centre staff feel it is not appropriate for the individual to participate (for example on the basis of poor temper control) they will not be included in the study.

All data collected in this study will be stored following NHS data management policies and the data protection act.

Before commencing the research proposals will be submitted to the West of Scotland Ethics Committee and then to each recruitment centres' research and development department. As the researcher is an employee of NHS Lanarkshire approval will be need to be sought from their research and development department.

**Practical Applications**

Waters and Bucks (2010) review paper reports that cognitive deficits increase as time awake increases but can be reduced when normal sleep patterns are restored. Sleep difficulties and cognitive impairments are common in those who have sustained a head injury. This study aims to show a relationship between sleep difficulties and cognitive impairments in patients who have a head injury. If the relationship is demonstrated this study could be a foundation for future research exploring how sleep intervention could help rehabilitate cognitive deficits that are exacerbated by sleep difficulties.

**References**


Aron, A. R., Robbins, T. W., & Poldrack, R. A. (2004). Inhibition and the right inferior frontal cortex. *Trends in Cognitive Sciences, 8*, 170–177.

Baddeley, A. D. (1986). *Working Memory.* Oxford: Oxford University Press.

Benton, A. (1968). Differential behavioral effects on frontal lobe disease. *Neuropsychologia, 6,* 53-60

Bloomfield, I., Espie, C., Evans, J (2010). Do sleep difficulties exacerbate deficits in sustained attention following traumatic brain injury? *Journal of the international neuropsychological* society 16, 17-25

Bonnet, M.H. & Arand, D.L.(1995). 24-hour metabolic rate in insomniacs and matched normal sleepers. *Sleep, 18,* 581–588.

Bruner, J., Goodnow, J. J., & Austin, G. A. (1956). *A study of thinking*. New York: John Wiley & Sons.

Burgess, P. W. & Shallice, T. (1996). Response suppression, initiation and strategy use following frontal lobe lesions. *Neuropsychologia, 34*, 263–272.

Buysse , D.J., Reynolds , C.F. III , Monk , T.H. , Berman , S.R. & Kupfer , D.J . (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research *Psychiatry Research* , *28* , 193 – 213

Campos-Morales, R.M., Valencia-Flores, M., Castan˜o-Meneses, A., Castan˜eda-Figueiras, S., & Martı´nez-Guerrero, J. (2005). Sleepiness, performance and mood in a group of Mexican undergraduate students. *Biological Rhythm Research,* 26, 9–13.

Cicerone, K.D., Dahlberg, C., Malec, J., Langenbahn, D., Felicetti, T., et al. (2005). Evidence basedCognitive rehabilitation: updated review of the literature from 1998–2002. *Archives of Physical Medicine Rehabilitation, 86*, 1681–92

Cohen. M., Oksenberg, A., Snir, D., Stern, M., Groswasser, Z. (1992) Temporally related changes of sleep complaints in traumatic brain injured patients*, Journal of neurology, neurosurgery, and psychiatry 55*, 313-315

Dinges, D. F., and Powell, J. W. (1985). Microcomputer analyses of performance on a portable, simple, visual RT task during sustained operations. *Behaviour Research Methods, Instruments, & Computers, 17*, 652–655.

Dinges,D. F., Pack, F., Williams, K., Gillen, K. A., Powell, J. W.,and Ott, G. E., et al., (1997). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 h per night. *Sleep, 20*, 267–277.

Fang, S., Huang, C., Yang, T., Tsai, P. (2008). Heart rate variability and daytime functioning in insomniacs and normal sleepers: preliminary results *Journal of Psychosomatic Research, 65*, 23–30

Fortier-Brochu, E., Beaulieu-Bonneau S, Ivers H, Morin C (2011) Insomnia and daytime cognitive performance: A meta-analysis *Sleep Medicine Reviews, 16,* 89-94

Gradisar, M., Terrill, G., Johnston, A., & Douglas, P. (2008) Adolescent sleep and working memory performance *Sleep and Biological Rhythms*, 6, 146–154.

Harrison, Y., & Horne, J.A. (1997). Sleep deprivation affects speech. *Sleep, 20*, 871–877.

Harrison, Y., & Horne, J.A. (1998). Sleep loss impairs short and novel language tasks having a prefrontal focus*. Journal of Sleep Research, 7,* 95–100.

Harrison, Y., & Horne, J.A. (2000). The impact of sleep deprivation on decision making: A review. *Journal Experimental Psychology Applied, 6*, 236–249.

Hoddes, E., Dement, W.E., and Zarcone, V. (1972) The history and use of the Stanford Sleepiness Scale. *Psychophysiology 9*, 150

Horne, J.A. (1993). Human sleep, sleep loss and behaviour. Implications for the prefrontal cortex and psychiatric disorder. *British Journal of Psychiatry, 162*, 413–419.

Horne, J.A. (1988). Why we sleep: The functions of sleep in humans and other animals. Oxford: Oxford University Press.

Hukkelhoven, C., Steyerberg, E., Farace, E., Habbema, D., Marshall, L., & Maas, A. (2002). Regional differences in patient characteristics, case management and outcomes in traumatic brain injury: experience from the tirilazad trials. *Neurosurgery 97*, 549–557

Killgore, W.D. (2010). Effects of sleep deprivation on cognition. *Progress in Brain Research 185*, 105-129

Lezak , M.D., Howieson, D.B., & Loring, D.W. (2004). *Neuropsychological Assessment* (4th ed.). New York : Oxford University Press

Lim, J., & Dinges, D. F. (2008). Sleep deprivation and vigilant attention. *Annals of the New York Academy of Sciences*, 1129, 305–322.

Lim, J., & Dinges, D. F. (2010).A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. *Psychological Bulletin,* 136, 375–389.

McDowell, S., Whyte, J., & D'Esposito, M. (1997). Working memory impairments in traumatic brain injury: evidence from a dual-task paradigm. *Neuropsychologia, 35*, 1341–1353.

McLean. A., Dikman, S., Temkin, N, (1993). Psychosocial recovery after head injury, *Archives of Physical Medicine Rehabilitation, 74*, 1041-1046

McLellan, D.L. (1991). Functional recovery and the principles of disability medicine. In *Clinical Neurology*, ed. M. Swash, J. Oxbury. Edinburgh, UK: Churchill Livingstone

Makley, M. J., English, J. B., Drubach, D.A., Kreuz, A. J., Celnik, P.A., & Tarwater, P.M. (2008). Prevalence of sleep disturbance in closed head injury patients in a rehabilitation unit. *Neurorehabilitation and Neural Repair*,*22*, 341-347.

Morin, C.M. (1993). *Insomnia: Psychological Assessment and Management*. New York: Guilford Press .

Nilsson, J.P., Soderstrom, M., Karlsson, A.U., Lekander, M., Akerstedt, T., Lindroth, N.E., & Axelsson, J. (2005). Less effective executive functioning after one night's sleep deprivation. *Journal of Sleep Research,* 14, 1–6

Oullet MC & Morin CM. (2007). Efficacy of cognitive-behavioral therapy for insomnia associated with traumatic brain injury: a single-case experimental design. *Archives of Physical Medical Rehabilitation 8*8, 1531-1492.

Rey, A. (1941). L'examen psychologique dans les cas d'ence´phalopathie traumatique. *Archives de Psychologie, 28*, 21

Robertson , I.H. , Manly , T. , Andrade , J. , Baddeley , B.T. , & Yiend , J (1997 ). 'Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects . *Neuropsychologia 35* , 747 – 758

Sadeh , A and Acebo , C . (2002). The role of actigraphy in sleep medicine . *Sleep Medicine Reviews*,*6* , 113 – 124 .

Shekleton, J.A., Rogers, N.L., Rajartnam, M.W. (2010). Searching for the day time impairments of daytime insomnia *Sleep Medicine Reviews 14,* 47-60

Tagliaferri, F., Compagnone, C., Korsie, M., Servadei, F., Kraus, J. (2006). A systematic review of brain injury epidemiology in Europe *Acta Neurochirurgica 148,* 255-268

Teasdale, G., & Jennett, B. (1974). "Assessment of coma and impaired consciousness. A practical scale" *Lancet, 2* 81–84

Turner, T.H., Drummond, S.P., Salamat, J.S., & Brown, G.G. (2007). Effects of 42 hr of total sleep deprivation on component processes of verbal working memory. *Neuropsychology, 21,* 787–795.

Van Dongen, H. P., Maislin, G., Mullington, J. M., and Dinges, D. F. (2003). The cumulative cost of additional wakefulness: Dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep,* 26, 117–126.

Varkevisser. M., Kerkhof, G.A. (2005). Chronic insomnia and performance in a 24-h constant routine study. *Journal of Sleep Research, 14*, 49–59.

Vignola, A., Lamoureux, C., Bastien, CH., Morin, C.M. (2000). Effects of chronic insomnia and use of benzodiazepines on daytime performance in older adults. *Journal of Gerontology,* 55, 54–62

Waters, F. and Bucks, R.S. (2011). Neuropsychological Effects of Sleep Loss: Implication for Neuropsychologists. *Journal of the International Neuropsychological Society 17,* 571–586

Wilson, B.A. (2008) Neuropsychological Rehabilitation. *Annual Review of Clinical Psychology* 4, 141-162

Wechsler, D . (1999) *Wechsler Abbreviated Scale of Intelligence (WASI)*. San Antonio, TX : The Psychological Corporation .

Wechsler, D. (2001) *WTAR Administration and Scoring Manual.* San Antonio, TX : The Psychological Corporation .

Zigmond , A.S., & Snaith , R.P. (1983) The hospital anxiety and depression scale . *Acta Psychiatrica Scandinavica* , *67* , 361 – 370

**Appendix 2.2 Research Ethics Approval Letter**

**WoSRES**
**West of Scotland Research Ethics Service**

NHS
Greater Glasgow and Clyde

**West of Scotland REC 3**
Ground Floor – The Tennent Institute
Western Infirmary
38 Church Street
Glasgow G11 6NT
www.nhsggc.org.uk

Professor Thomas McMillan
Professor of Clinical Neuropsychology
University of Glasgow
Mental Health and Wellbeing
1055 Great Western Road
Glasgow
G12 0XH

Date 1st November 2012
Your Ref
Our Ref
Direct line 0141 211 2123
Fax 0141 211 1847
E-mail Liz.Jamieson@ggc.scot.nhs.uk

Dear Professor McMillan

**Study title:** **Do sleep difficulties exacerbate cognitive deficits following head injury in an inpatient rehabilitation population?**
**REC reference:** **12/WS/0264**
**IRAS Project reference:** **111371**

The Research Ethics Committee reviewed the above application at the meeting held on 25 October 2012. Thank you to Allan Thomson for attending to discuss the study.

The Committee thanked Mr Thomson for the resubmission commenting that the only outstanding issue was the confounding variables which had not been taken into account, some of which could have an impact on sleep. He advised that it was the 'group effect' that was being studied but accepted the comment indicating that these issues would be noted when analysing the data.

The Committee discussed Mr Thomson's response around confounding variables and would like to suggest that Mr Thomson should try to produce evidence that the profile of both groups once identified are reasonably equitable, e.g. previous alcohol consumption, mental illness, substance misuse and time since injury etc.

The members of the Committee present gave a favourable ethical opinion of the above research on the basis described in the application form, protocol and supporting documentation, subject to the conditions specified below.

**Ethical review of research sites**

NHS Sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

**Statement of compliance**

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

**After ethical review**

Reporting requirements

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

Feedback

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

Further information is available at National Research Ethics Service website > After Review

| **12/WS/0264** | **Please quote this number on all correspondence** |
|---|---|

With the Committee's best wishes for the success of this project

Yours sincerely

**Liz Jamieson**
**Committee Co-ordinator**
**On behalf of Dr Adam Burnel, Chair**

| | |
|---|---|
| Enclosures: | List of names and professions of members who were present at the meeting and those who submitted written comments<br>"After ethical review – guidance for researchers" |
| Copy to: | Mr Raymond Hamill, R&D – NHS Lanarkshire |

**West of Scotland REC 3**

**Attendance at Committee meeting on 25 October 2012**

**Committee Members:**

| *Name* | *Profession* | *Present* | *Notes* |
|---|---|---|---|
| Dr Adam Burnel | Consultant Psychiatrist - Chair | Yes | |
| Mrs Bernadette Campbell | Primary Care Support Nurse | No | |
| Ms Susan Fleming | Public Health Researcher | Yes | |
| Dr Judith Godden | Scientific Officer/Manager | No | |
| Dr Anja Guttinger | Consultant in Sexual & Reproductive Health | No | |
| Mrs Mary Keenaghan | Clinical Auditor | No | |
| Mr Eoin MacGillivray | Lay Member - Vice Chair | Yes | |
| Dr Paul Mattison | Consultant Physician in Rehabilitation Medicine | Yes | |
| Dr Angus McFadyen | Reader in Health Statistics | Yes | |
| Dr Stuart Milligan | Lecturer in Palliative and Cancer Care | Yes | |
| Dr Stephen Noble | Consultant Anaesthetist | No | |
| Mrs Gillian Notman | Joint Occupational Therapy Lead Advisor | Yes | |
| Mrs Helen Ross | Lay Member | Yes | |
| Mrs Rosie Rutherford | Lay Member | Yes | |

**Also in attendance:**

| *Name* | *Position (or reason for attending)* |
|---|---|
| Mrs Liz Jamieson | Committee Co-ordinator |

**Written comments received from:**

| *Name* | *Position* |
|---|---|
| Mrs Bernadette Campbell | Primary Care Support Nurse |
| Dr Anja Guttinger | Consultant in Sexual & Reproductive Health |
| Dr Stephen Noble | Consultant Anaesthetist |

## Appendix 2.3 NHS Lanarkshire R&D Approval Letter



NHS Lanarkshire

Professor Thomas McMillan
Professor of Clinical Neuropsychology
University of Glasgow
Mental Health and Wellbeing
1055 Great Western Road
Glasgow, G12 0XH

R&D Department
Corporate Services Building
Monklands Hospital
Monkscourt Avenue
AIRDRIE
ML6 0JS

Date 15 November 2012
Enquiries to Margaret Stewart
R&D Facilitator
Direct Line 01236 712445
Email Margaret.stewart@lanarkshire.scot.nhs.uk

Dear Professor McMillan

**PROJECT TITLE: Do sleep difficulties exacerbate cognitive deficits following head injury in an inpatient rehabilitation population?**

**R&D ID NUMBER: L12048**

I am writing to you as Chief Investigator of the above study to advise that R&D Management approval has been granted for the conduct of your study within NHS Lanarkshire as detailed below:

| NAME | TITLE | ROLE | NHSL SITE TO WHICH APPROVAL APPLIES |
|---|---|---|---|
| Allan Thomson | Trainee Clinical Psychologist | Local Collaborator / Principal Investigator | NHS Lanarkshire |

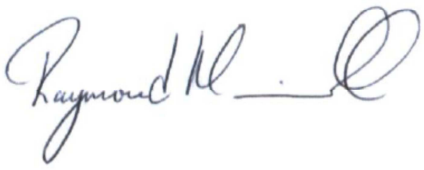
As you are aware, NHS Lanarkshire has agreed to be the Sponsor for your study. On its behalf, the R&D Department has a number of responsibilities; these include ensuring that you understand your own role as Chief Investigator of this study. To help with this we have outlined the responsibilities of the Chief Investigator in the attached document for you information.

All research projects within NHS Lanarkshire will be subject to annual audit via a questionnaire that we will ask you to complete. In addition, we are required to carry out formal monitoring of a proportion of projects, in particular those projects that are Sponsored by NHS Lanarkshire. In either case, you will find it helpful to maintain a well organised Site File. A folder will be sent to you separately in the mail for this purpose.

Cont/....

I trust these conditions are acceptable to you.

Yours sincerely,



**Raymond Hamill**
**Research & Development Manager**

Enc 1 x Site File
1 x Responsibilities as Sponsor Notes

cc.

| NAME | TITLE | CONTACT ADDRESS | ROLE |
|---|---|---|---|
| Alan Thomson | Trainnee Clinical Psychologist | Coathill Hospital | Principal Investigator / Local Collaborator |

**cc. via email:**
alan.thomson@lanarkshire.scot.nhs.uk

## Appendix 2.4 Huntercombe Services Research Approval

the huntercombe group

The Huntercombe Hospital - Maidenhead
Huntercombe Lane South
Taplow, Maidenhead
Berkshire SL6 0PQ

t 01628 667 881
f 01628 662 087
e huntercombe.maidenhead@fshc.co.uk

www.huntercombe.com

Professor Thomas McMillan
University of Glasgow
Mental Health and Wellbeing
1055 Great Western Road
Glasgow
G12 0XH

16th October 2012

Dear Tom,

**Project title: Do sleep difficulties exacerbate cognitive deficits following head injury in an inpatient rehabilitation population?**

Thank you for your recent application to the RPGG for the above project.

The RPGG has decided that this study be given conditional approval conditional upon obtaining NHS Ethical approval. Once obtained, a scanned copy of the approval letter should be forwarded to the RPGG Research Co-ordinator, Mark Rose at mark.rose@fshc.co.uk.

Yours sincerely

Lynn McLeish
Director of Brain Injury & Neurodisability Services

c.c.: Catherine Symington – General Manager, Murdostoun

## Appendix 2.5 Research Minor Amendment Approval

**WoSRES**
**West of Scotland Research Ethics Service**

NHS
Greater Glasgow and Clyde

**West of Scotland REC 3**
Ground Floor – The Tennent Institute
Western Infirmary
38 Church Street
Glasgow G11 6NT
www.nhsggc.org.uk

Professor Thomas McMillan
Professor of Clinical Neuropsychology
University of Glasgow
Mental Health and Wellbeing
1055 Great Western Road
Glasgow
G12 0XH

Date 12th December 2012
Your Ref
Our Ref
Direct line 0141 211 2123
Fax 0141 211 1847
E-mail Liz.Jamieson@ggc.scot.nhs.uk

Dear Professor McMillan

**Study title:** **Do sleep difficulties exacerbate cognitive deficits following head injury in an inpatient rehabilitation population?**
**REC reference:** **12/WS/0264**
**Amendment number:** **AM01**
**Amendment date:** **30 November 2012**
**IRAS project ID:** **111371**

Thank you for your email of 30 November 2012, notifying the Committee of the above amendment, i.e. a minor change to the inclusion criteria from 'those who have had a head injury within the last year' to 'those who have had a head injury'.

The Committee does not consider this to be a "substantial amendment"as defined in the Standard Operating Procedures for Research Ethics Committees. The amendment does not therefore require an ethical opinion from the Committee and may be implemented immediately, provided that it does not affect the approval for the research given by the R&D office for the relevant NHS care organisation.

**Documents received**

The documents received were as follows:

| Document | Version | Date |
|---|---|---|
| Participant Consent Form | 1.2 | 30 November 2012 |
| Participant Information Sheet | 1.2 | 30 November 2012 |
| Protocol | 1.5 | 30 November 2012 |
| Notification of a Minor Amendment | AM01 | 30 November 2012 |

**Statement of compliance**

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

| 12/WS/0264: | Please quote this number on all correspondence |
|---|---|

Yours sincerely

**Mrs Liz Jamieson**
**Committee Co-ordinator**

Copy to: Mr Raymond Hamill, NHS Lanarkshire

**Appendix 2.6 Research Substantial Amendment Approval**

**WoSRES**
**West of Scotland Research Ethics Service**

NHS
Greater Glasgow and Clyde

**West of Scotland REC 3**
Ground Floor – The Tennent Institute
Western Infirmary
38 Church Street
Glasgow G11 6NT
www.nhsggc.org.uk

Professor Thomas McMillan
Professor of Clinical Neuropsychology
University of Glasgow
Institute of Health & Wellbeing,
1st Floor, Administration Building
Gartnavel Royal Hospital,
1055 Great Western Road
Glasgow
G12 0XH

Date 27th February 2013
Your Ref
Our Ref
Direct line 0141 211 2123
Fax 0141 211 1847
E-mail Liz.Jamieson@ggc.scot.nhs.uk

Dear Professor McMillan

**Study title:** **Do sleep difficulties exacerbate cognitive deficits following head injury in an inpatient rehabilitation population?**
**REC reference:** **12/WS/0264**
**Amendment number:** **AM02**
**Amendment date:** **15 February 2013**
**IRAS project ID:** **111371**

The above amendment was reviewed by the Sub-Committee in correspondence.

**Ethical opinion**

Initially the Sub Committee had concerns about the approach being made to recruit the participants from Graham Anderson House. However after clarification from Allan Thomson the Sub Committee was satisfied that the recruitment method was appropriate for this group.

The members of the Committee taking part in the review gave a favourable ethical opinion of the amendment on the basis described in the notice of amendment form and supporting documentation.

**Approved documents**

The documents reviewed and approved at the meeting were:

| Document | Version | Date |
|---|---|---|
| Participant Consent Form | 1.3 | 18 January 2013 |
| Participant Information Sheet | 1.3 | 18 January 2013 |
| Protocol | 1.6 | 18 January 2013 |
| Notice of Substantial Amendment (non-CTIMPs) | AM02 | 15 February 2013 |

**Membership of the Committee**

The members of the Committee who took part in the review are listed on the attached sheet.

**R&D approval**

All investigators and research collaborators in the NHS should notify the R&D office for the relevant NHS care organisation of this amendment and check whether it affects R&D approval of the research.

**Statement of compliance**

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

We are pleased to welcome researchers and R & D staff at our NRES committee members' training days – see details at http://www.hra.nhs.uk/hra-training/

| | |
|---|---|
| **12/WS/0264:** | **Please quote this number on all correspondence** |

Yours sincerely

**Liz Jamieson**
**Committee Co-ordinator**
**On behalf of Dr Adam Burnel, Chair**

| | |
|---|---|
| Enclosures: | List of names and professions of members who took part in the review |
| Copy to: | Mr Raymond Hamill, NHS Lanarkshire |

**Appendix 2.7 Participant Information Sheet**

Mental Health and Well being

Gartnavel Royal Hospital
1055 Great Western Road
Glasgow

**Participant Information Sheet**

Do sleep difficulties exacerbate cognitive deficits following Head Injury in an inpatient rehabilitation population?

We would like to invite you to take part in a research study. Before you decide, you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish.

**Who is conducting the research?**

This study is being carried out by Allan Thomson and Eleni Morfiri, Trainee Clinical Psychologists and is being supervised by Professor Thomas McMillan and Dr Maria Gardani from the University of Glasgow.

**What is the purpose of this study?**

This study aims to explore how sleep affects attention, memory and executive functions in people who have had a head injury. Attention is the ability to focus on a task. Memory is the ability to retain and recall information over time. Executive functions are the cognitive processes that regulate an individual's ability to organize thoughts and activities, prioritise tasks, manage time efficiently, and make decisions.

The study will be submitted as part of Allan Thomson's research portfolio for examination by the University of Glasgow in partial fulfilment for the degree of Doctorate in Clinical Psychology.

**Why have I been invited?**

You have been invited to take part in this study as you are aged 18-64 years old, have had an acquired brain injury and are currently an in-patient in a rehabilitation centre. You have been in rehabilitation for at least 3 weeks.
You cannot take part in this study if any of the following criteria applies to you;

- You have a sleep disorder such as sleep apnoea, narcolepsy, restless legs or periodic limb movement disorder.
- You are currently undergoing severe psychiatric symptoms
- You are currently being treated for an alcohol and/or drugs problem
- You have a learning disability.
- You have vision or hearing impairment
- You are not a native English speaker.

**Do I have to take part?**

It is up to you to decide. We will describe the study and go through this information sheet, which we will then be given to you. We will then ask you to sign a consent form to show you have agreed to take part. You are free to withdraw at any time, without giving a reason. This would not affect the standard of care you receive.

**What will happen to me if I take part?**

Taking part involves the researchers accessing your medical records held by the rehabilitation centres to review information relating to your head injury and sleep. Researchers will then interview you about your sleep and complete some questionnaires with you relating to your sleep and mood. You will be asked to keep a sleep diary for 7 days. If you are not able to complete the sleep diary rehabilitation centre staff will help you do this. While you are keeping your sleep diary you will be asked to wear a special watch called an "acti-watch" for 7 days. This watch will measure your activity for the 7 days. You will only take the acti-watch off when you are washing or carrying out an activity where it may get wet. Rehabilitation centre staff will remind you to take of the watch and to put it back on.

You may have participated recently in a similar study collecting this data. If so we will ask if we could use the data and this will mean that we would not need to ask you to complete any of the above again.

The next part of the study involves you completing a number of short tests. These tests are like puzzles and help measure our attention, memory and executive functions. Some of the test will be completed on a computer and other tests will involve the researcher noting your responses. This part of the study will take approximately 70 minutes. If you feel you are getting tired completing these tests we could finish doing them on another day.

**What happens to the information?**

Your identity and personal information will be kept completely confidential and known only to the research team. The data will be held in accordance with the Data Protection Act, which means that we keep it safely and cannot reveal it to other people, without your permission.

**What are the potential benefits of taking part?**

It is hoped by taking part in this study we will learn how sleep affects people's attention, memory and executive functioning after head injury. If a relationship is found this study may provide a foundation for future research developing sleep interventions that may also help improve attention, memory and executive functioning difficulties.

**Who has reviewed this study?**
This study has been reviewed by the West of Scotland Ethics Committee, NHS Lanarkshire Research and Development Department and the rehabilitation centres research and development departments.
**If you have any further questions?**

We will give you a copy of this information sheet and the signed consent forms to keep. If you would like more information about the study and wish to speak to someone not closely linked to the study,

please contact Dr Sue Turnbull, University of Glasgow, Mental health and Well-being, 1055 Great Western Road, Glasgow, G12 0XH Tel: 0141 211 0607 Email: susan.turnbull@glasgow.ac.uk

**If you have a complaint about any aspect of the study?**

If you are unhappy about any aspect of the study you can speak to any of the rehabilitation team or research team in the first instance. If this does not alleviate your concerns the normal NHS complaint procedures are open to you.

**Research team contact details**:
*Chief Investigator/Research Supervisor.*
Professor Thomas McMillan
Professor of Clinical Neuropsychology
University of Glasgow
Mental health and Well-being
1055 Great Western Road
Glasgow, G12 0XH
Email: Thomas.McMillan@glasgow.ac.uk
Tel: 0141 211 0607

*Research Supervisor*
Dr Maria Gardani
Research Associate
University of Glasgow
Mental health and Well-being
1055 Great Western Road
Glasgow, G12 0XH
Email: maria.gardani@glasgow.ac.uk
Tel: 0141 211 0607

Researchers
Allan Thomson/ Eleni Morfiri
Trainee Clinical Psychologists
University of Glasgow
Mental health and Well-being
1055 Great Western Road
Glasgow, G12 0XH
Email: a.thomson.4@research.gla.ac.uk / e.morfiri.1@research.gla.ac.uk
Tel: 0141 211 0607

***Thank you for taking the time to read this information sheet.***

**Appendix 2.8 Participant Consent Form**

Mental Health and Well being

Gartnavel Royal Hospital
1055 Great Western Road
Glasgow
Participant Identification number:

**CONSENT FORM**

**Do sleep difficulties exacerbate cognitive deficits following head injury in an inpatient rehabilitation population?**

Names of researchers: Allan Thomson and Eleni Morfiri.

*Please initial box*

1. I confirm that I have read and understand the participant information sheet dated 18/1/2013 (version 1.3) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. ☐
3. I understand that relevant sections of my medical notes and data collected may be looked at by the researchers, regulatory authorities, University of Glasgow and NHS Lanarkshire, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records. ☐
4. I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available. ☐
5. I have participated in the prevalence, types and correlates of sleep problems in head injury patients during the rehabilitation period study and agree that information obtained previously can be accessed by researchers in this study. ☐
6. I agree to my participation being recorded in my rehabilitation notes. ☐
7. I agree to take part in the above study. ☐

| **Name of Participant** | **Date** | **Signature** |
|---|---|---|
| **Name of Person taking consent** | **Date** | **Signature** |

When completed: 1 for patient, 1 for researcher site file, 1 (original) to be kept in rehabilitation notes

## Appendix 2.9 Guidelines for Submission to the Journal of the International Neuropsychological Society

### JOURNAL OF THE INTERNATIONAL NEUROPSYCHOLOGICAL SOCIETY

**Instructions for Contributors**

**Aims and Scope:**
The *Journal of the International Neuropsychological Society* welcomes original, creative, high quality research papers covering all areas of neuropsychology. The focus of articles may be primarily experimental, more applied or clinical. Contributions will broadly reflect the interest of all areas of neuropsychology, including but not limited to: development of cognitive processes, brain-behavior relationships, adult and pediatric neuropsychology, neurobehavioral syndromes, such as aphasia or apraxia, and the interfaces of neuropsychology with related areas such as behavioral neurology, neuropsychiatry, and cognitive neuroscience. Papers that utilize behavioral, neuroimaging, and electrophysiological measures are appropriate. Book reviews will also be published.

To assure maximum flexibility and to promote diverse mechanisms of scholarly communication, the following formats are available in addition to *Regular Research Articles: Brief Communications* are shorter research articles; *Rapid Communications* are intended for "fast breaking" new work, that does not yet justify a full length article, and which are put on a fast review track; *Neurobehavioral Grand Rounds* are unique case studies, which are published in tandem with an introduction by an expert in the field to put the case into a more global perspective; *Critical Reviews* are thoughtful considerations of topics of importance to neuropsychology, including associated areas, such as functional brain imaging, neuroepidemiology, and ethical issues; *Dialogues* provide a forum for publishing two distinct positions on controversial issues in a point-counterpoint form; *Symposia* consist of several research articles that are thematically linked; *Letters to the Editor* respond to recent articles in the *Journal of the International Neuropsychological Society;* and *Book Reviews.*

*Critical Reviews, Dialogues,* and *Symposia* may be invited by the appropriate Department Editor or proposed by individual authors. Such proposals should be discussed with the Editor-in-Chief or the Department Editor before submission. *Book Reviews* are invited by the Book Review Editor.

**Originality and Copyright**
To be considered for publication in the *Journal of the International Neuropsychological Society,* a manuscript cannot have been published previously, nor can it be under review for publication elsewhere. Papers with multiple authors are reviewed with the assumption that all authors have approved the submitted manuscript and concur with its submission to the *Journal of the International Neuropsychological Society.* **A Copyright Transfer Agreement**, with certain specified rights reserved by the author, must be signed and returned to the Editor by the corresponding author of accepted manuscripts, prior to publication. This is necessary for the wide distribution of research findings, and the protection of both author and the society under copyright law.

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The **Author Disclosure Form** must be signed by the corresponding author for all the manuscript's authors at the time the manuscript is submitted. This form includes an attestation that the manuscript is original and not under review in another journal, research was conducted in compliance with institutional guidelines, and any potential conflicts of interest have been reported. Such disclosure will not preclude publication, but it is critical because of the potential of negative or positive bias. Potential conflicts of interest include funding sources for the reported study (e.g., a test validation study financially supported by a test publisher, a study supported by an insurance company), personal or family financial interest in a test or product or with a company that publishes a test that is being investigated in the manuscript or competes with a test that is being investigated in the manuscript. Other conflicts include employment, consultancies, stock ownership or medicolegal work. For the latter, information about whether the author's medicolegal work is largely for one side should be reported. This list of potential conflicts is not all inclusive, and it is the responsibility of each author to ensure that all of their "potential conflicts" are reported in the Acknowledgment section of the paper. Authors should err on the side of full disclosure, and if authors are uncertain about what constitutes a relevant conflict, they should contact the editorial office (jins@unm.edu).

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**Manuscript Submission and Review**
The *Journal of the International Neuropsychological Society* uses online submission and peer review. Paper submissions are not accepted. Authors who are not able to submit their manuscripts online are asked to contact the editorial office at: jins@unm.edu. The website address for submissions is: http://mc.manuscriptcentral.com/cup/jins, and complete instructions are provided on the website. Prior to online submission, please consult http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=mesh for 6 keywords or mesh terms that are different from words in the title. Accurate mesh terms will increase the probability that your manuscript will be identified in online searches. Please follow the instructions carefully to avoid delays. The menu will prompt the author to provide all necessary information, including the manuscript category, the corresponding author including phone number, fax number and e-mail address, and suggested reviewers.

The website will automatically acknowledge receipt of the manuscript and provide a manuscript reference number. The Editor-in-Chief will assign the manuscript for review to an Associate or Department Editor and at least two other reviewers. Every effort will be made to provide the author with a review within 6 to 10 weeks of manuscript assignment. *Rapid Communications* will be reviewed within 6 weeks. If the Editor requests that revisions be made to a manuscript before publication, a maximum of 3 months will be allowed for preparation of the revision, except in unusual circumstances.

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In order to increase the number of manuscripts that can be published in the *JINS,* please adhere to the following length requirements. Please provide a word count on the title page for abstract and for manuscript (not including abstract, tables, figures, or references). Manuscripts will be returned if they exceed length requirements.

**Regular Research Articles:** Maximum of 5,000 words (not including tables, figures, or references) and a 200 word abstract.

**Brief Communications:** Maximum of 2,500 words (not including abstract, tables, figures, or references) and a 150 word abstract, with a maximum of two tables or two figures, or one table and one figure, and 20 references.

**Rapid Communications:** Maximum of 1,000 words (not including abstract, tables, figures, or references) and a 150 word abstract, with a maximum of two tables or two figures, or one table and one figure, and 10 references.

**Critical Reviews:** Maximum of 7,000 words (not including abstract, tables, figures, or references) and a 200 word abstract. ***Critical Reviews* must be pre-approved by the Department Editor. Please e-mail your abstract to jins@unm.edu in order to receive prior approval.**

**Short Reviews:** Maximum of 2,500 words, a 100-word abstract, and 35 references. *Short Reviews* are conceptually-oriented snapshots of the current state of a research area rather than comprehensive reviews. We welcome descriptions of new or recent concepts and their applicability to neuropsychology, and proposals of novel ideas or approaches, particularly if they lead to testable hypotheses. Prose should be readily accessible to both students and seasoned scientists and clinicians. ***Short Reviews* are written by recognized experts in their field. Generally, they are submitted by invitation only, but occasionally an invitation may be issued on the basis of an unsolicited proposal.**

**Dialogues:** Maximum of 2,000 words for each segment (not including abstract, tables, figures, or references) and a 100 word abstract, with a maximum of two tables or two figures, or one table and one figure and 20 references. ***Dialogues* must be pre-approved by the Department Editor. Please e-mail your abstract to jins@unm.edu in order to receive prior approval.**

**Symposia:** Maximum of 5,000 words (not including abstract, tables, figures, or references) and a 200 word abstract. ***Symposia* must be pre-approved by the Department Editor. Please e-mail your abstract to jins@unm.edu in order to receive prior approval.**

**Neurobehavioral Grand Rounds:** Maximum of 5,000 words with an informative literature review (not including abstract, tables, figures, or references) and a 200 word abstract.

**Letters to the Editor:** Maximum of 500 words (not including table, figure, or references) with up to five references, one table, or one figure.

**Book Reviews:** Approximately 1,000 words.

**Manuscript Preparation and Style**

The entire manuscript should be typed double-spaced throughout using any word processing program. Unless otherwise specified, the guideline for preparation of manuscripts is the *Publication Manual of the American Psychological Association* (6th edition). This may be ordered from: APA Order Dept., 750 1st St. NE, Washington, DC 20002-4242, USA.

Pages should be numbered sequentially beginning with the Title Page. The Title Page should contain the full title of the manuscript, the full names and affiliations of all authors, a contact address with telephone and fax numbers and e-mail address, and the word count for abstract and for manuscript (excluding title page, abstract, references, tables, and figures). At the top right provide a short title of up to 45 characters preceded by the lead author's last name. Example: Smith-Memory in Parkinson's Disease. This running headline should be repeated at the top right of every following page.

The Abstract and Mesh terms (Keywords) on *page 2* should include a brief statement of the problem, the method, the key findings, and the conclusions. Six mesh or key words should be provided (see http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=mesh for list), and they should not duplicate words in the title.

The full text of the manuscript should begin on *page 3*. For scientific articles, including *Regular Research Articles, Brief Communications, Rapid Communications,* and *Symposia,* the format should include an Abstract, Introduction, Method, Results, and Discussion. This should be followed by References, Appendixes, Acknowledgments, Tables, Figures, and Figure Legends.

The use of abbreviations, except those that are widely used, is strongly discouraged. They should be used only if they contribute to better comprehension of the manuscript. Acronyms should be spelled out at first mention. Metric system (SI) units should be used.

**Special Note Regarding Figures**

Please upload your figure(s) in either a .doc or pdf. format. When uploading figures (color or black and white), they need only be a high enough resolution for the reviewers and editors to identify the information you are trying to convey. However, if your manuscript is accepted for publication, your figures must meet the following criteria:

High quality digital images (600 dpi or higher) should be provided in PDF, EPS, or TIFF formats. If a digital image is not available, please scan in the image. Figures should be numbered consecutively as they appear in the text. Any indication of features of special interest should also be included. Figures should be twice their intended final size and authors should do their best to construct figures with notation and data points of sufficient size to permit legible photo reduction to one column of a two-column format.

Color figures can be accepted. All color graphics must be formatted in CMYK and not in RGB, because 4-color separations cannot be done in RGB. However, the extra cost of printing these figures must be paid by the author: $500 for the first color page, $250 for each color page thereafter.

Tables and figures should be numbered in Arabic numerals. The approximate position of each table and figure should be provided in the manuscript: [INSERT TABLE 1 HERE]. Tables and figures should be on separate pages. Tables should have short titles and all figure legends should be on separate pages.

If you plan to use figures or tables that have been redrawn or modified from other publications, and you are not the copyright holder, please obtain permission for this re-use. Authors should err on the side of caution and seek advice from the editorial office if they are uncertain whether to seek permission.

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Please provide details of the sources of financial support for all authors, including grant numbers. For example, "This work was supported by the National Institutes of Health (grant number XXXXXXX)". Multiple grant numbers should be separated by a comma and space, and where research was funded by more than one agency the different agencies should be separated by a semi-colon, with "and" before the final funder. Grants held by different authors should be identified as belonging to individual authors by the authors' initials. For example, "This work was supported by the Wellcome Trust (A.B., grant numbers XXXX, YYYY), (C.D., grant number ZZZZ); the Natural Environment Research Council (E.F., grant number FFFF); and the National Institutes of Health (A.B., grant number GGGG), (E.F., grant number HHHH)." Where no specific funding has been provided for research, please provide the following statement "This research received no specific grant from any funding agency, commercial or not-for-profit sectors."

**References**

References should be in American Psychological Association, 6th Edition, style (see the examples presented below).

Text references should be cited as follows: ". . . Given the critical role of the prefrontal cortex (PFC) in working memory (Cohen et al., 1997; Goldman-Rakic, 1987; Perlstein et al., 2003a, 2003b) . . ." with multiple references in alphabetical order. Another example is: "For example, Cohen et al. (1994,1997), Braver et al. (1997), and Jonides and Smith (1997) demonstrated . . ." References cited in the text with two authors should list both names. References cited in the text with three, four, or five authors, list all authors at first mention; with subsequent citations, include only the first author's last name followed by et al. References cited in the text with six or more authors should list the first author et al. throughout. In the reference section, list all authors up to seven. For eight or more, list the first six, then three ellipses, and end with the last author's name. Examples of the APA reference style are as follows:

**Online/Electronic Journal Article with DOI:**
Dikmen, S., Machamer, J. Fann, J. & Temkin, N. (2010). Rates of Symptom Reporting Following Traumatic Brain Injury. *Journal of the International Neuropsychological Society, 16,* 401-411. doi: 10.1017/S1355617710000196

**Scientific Article:**
Haaland, K.Y., Price, L., & LaRue, A. (2003). What does the WMS-III tell us about memory changes with normal aging? *Journal of the International Neuropsychological Society, 9,* 89-96.

**Book:**
Lezak, M.D., Howieson, D.B., & Loring, D.W. (2004). *Neuropsychological Assessment.* New York: Oxford University Press.

**Book Chapter:**
Knopman, D. & Selnes, O. (2003). Neuropsychology of Dementia. In K.M. Heilman & E.E. Valenstein (Ed.), *Clinical Neuropsychology.* New York: Oxford University Press.

**Report at a Scientific Meeting:**
Rothi, L.J.G. (2003, February). Use-dependent learning and neural plasticity: A revision of the pessimism surrounding neurorehabilitation. International Neuropsychological Society, Honolulu, Hawaii.

**Manual, Diagnostic Scheme, etc.:**
American Psychiatric Association (1994). *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.). Washington, DC: American Psychiatric Association Press.

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**Appendix. 2.10: Individual Subtest Scores and Pearson Correlations for PSQI and sleep efficiency scores.**

| ***Individual Subtest*** | ***Mean (SD)*** <br> ***(n=20)*** | ***Pearson Correlation*** <br> ***PSQI*** <br> ***(n=20)*** | ***Pearson Correlation*** <br> ***Sleep Efficiency*** <br> ***(n=20)*** |
|---|---|---|---|
| *SART number of Errors of Commission* | 15.65 (6.98) | r= 0.09, p=0.69 | **r= -0.7, p=0.001** |
| *SART number of Errors of Omission* | 36.9 (27.02) | r= 0.17, p=0.46 | r= 0.28, p=0.24 |
| *SART average Reaction Time (milliseconds)* | 434.34 (125.06) | r= 0.05 p=0.84 | **r=0.49, p=0.03** |
| *PVT percentage accuracy* | 83.95 (28.32) | r=-0.13, p=0.59 | r= 0.34, p= 0.14 |
| *PVT Average Reaction Time* | 449.20 (110.11) | r=-0.03, p=0.89 | r=-0.08, p= 0.73 |
| *LNS total number of correct responses* | 5.65 (2.85) | r= -0.18 p=0.44 | r=-0.004, p=0.99 |
| *FAS total number of words recalled* | 21.8 (9.37) | r= 0.17 p= 0.46 | r=0.02, p= 0.94 |
| *FAS total number of perseveration errors* | 3.25 (3.39) | r= -0.09, p=0.70 | r=-0.10, p=0.68 |
| *mSET total score* | 1.35 (1.27) | **r= 0.47, p= 0.04** | r=-0.27, p=0.24 |
| *Hayling total response time part A (seconds)* | 40 (29.24) | r= 0.15, p= 0.54 | r= -0.06, p=0.79 |
| *Hayling total response time part B (seconds)* | 80.9 (82.84) | r=0.24, p= 0.32 | r=0.10, p=0.66 |
| *Hayling total number of category A errors* | 4.9 (3.93) | r= 0.15, p=0.54 | r= -0.21,p= 0.36 |
| *Hayling total number of category B errors* | 4.4 (2.05) | r= 0.13, p = 0.58 | r= 0.39, p= 0.08 |
| *Hayling overall scaled score* | 2.3 (1.42) | r= 0.25, p= 0.29 | r= 0.12, p= 0.62 |
| *RAVLT immediate recall total score (number of words* | 26.65 (10.22) | **r= 0.48, p= 0.03** | r= -0.33, p= 0.16 |

| | | | |
|---|---|---|---|
| *recalled)* | | | |
| *RAVLT delayed recall total score (number of words recalled)* | 3.2 (3.24) | **r= 0.52, p= 0.02** | r= -0.33, p= 0.16 |
| *RAVLT recognition total score (Number of words recognised)* | 10.7 (4.9) | r= 0.40, p= 0.08 | r= -0.27, p= 0.26 |
| *RAVLT total number false positives recognition trial (Number of words incorrectly recognised)* | 5.9 (6.88) | r= 0.02, p= 0.95 | r= 0.23, p=0.33 |

*Significant associations highlighted in **bold***