

**INVESTIGATION OF A “DÉJÀ VÉCU” DELUSION IN A  
SINGLE CASE WITH MATCHED CONTROLS**

**MARTHA TURNER**

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## OVERVIEW

This thesis is concerned with the neuropsychology and rehabilitation of memory disorders, specifically with the remediation of memory disorders using compensatory external aids, and the exploration of the cognitive mechanisms underlying memory disorders using a single case approach.

Part 1 of the thesis systematically reviews the existing literature concerning the use of external memory aids in the cognitive rehabilitation of memory. In recent years there has been increased interest in compensatory approaches using external aids (for example diaries or electronic devices) to support memory functioning. Part 1 aimed to systematically assess the evidence for the effectiveness of this type of approach, and evaluate the state of current knowledge about which external aids, which training procedures, and which patient characteristics might be associated with the best outcomes.

Part 2 presents a single case with *déjà vécu* resulting from a head injury, and experimentally explores the cognitive mechanisms underlying the condition using a neuropsychological single case design. *Déjà vécu* is a rare memory disorder in which patients have the repeated experience that they have lived through the present moment before. However the cognitive mechanisms underlying it are poorly understood. Part 2 aims to investigate the cognitive basis of *déjà vécu* with a view to informing both our understanding of normal memory processing, and how to rehabilitate memory disorders of this type.

Finally Part 3 appraises the work presented, by expanding on methodological limitations, and reflecting on the extent to which the study was able to achieve the objectives of informing our understanding of normal memory function, or of how to rehabilitate déjà vécu and related paramnesic disorders.

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## **PART ONE: LITERATURE REVIEW**

### **The Use of External Memory Aids in the Cognitive Rehabilitation of Memory: A Systematic Review**

## **ABSTRACT**

### *Aims:*

To evaluate the use of external aids in cognitive rehabilitation for memory impairment in patients with acquired brain injury resulting from TBI and stroke.

### *Methods:*

Studies evaluating external aids published up to 2008 were extracted from the systematic reviews of cognitive rehabilitation by Cicerone and colleagues (Cicerone et al., 2000, 2005, 2011). In addition Medline, PschINFO and CINAHL-Plus were searched from 2008 up to March 2012. The reference lists of relevant articles were scanned to identify any additional studies.

### *Results:*

39 studies were reviewed. 12 studies evaluated paper-based aids and 27 studies evaluated electronic aids. All studies reported improvements in memory functioning associated with use of an external aid, although only one study directly compared an external memory aid to alternative memory interventions.

### *Conclusions:*

External aids are an effective tool in the rehabilitation of memory impairment following TBI and stroke. Further research is required to explore whether particular aids are differentially suited to particular types of patient or memory problem, and to explore the factors that are predictive of sustained use after discharge.

## **1. INTRODUCTION**

Cognitive impairments are common after brain injury, with memory deficits being amongst the most frequent complication (Wilson, 2009). Memory impairments may involve difficulty recalling information and events from the past (retrospective memory) as well as difficulty remembering to carry out tasks in the future (prospective memory). As such they have a considerable impact upon personal independence and social and vocational functioning. Unfortunately memory impairments are also amongst the most complex to remediate, as remembering to use a memory strategy is a memory task in itself.

In recent years there has been increased interest in evaluating cognitive rehabilitation after brain injury, with a flurry of publications concerned with evaluating the efficacy of various cognitive rehabilitation approaches. Cicerone and colleagues (Cicerone et al., 2000; 2005; 2011) in a series of systematic reviews, have found support for the effectiveness of cognitive rehabilitation following traumatic brain injury (TBI) and stroke for a range of cognitive impairments, including memory impairment. Practice recommendations and standards for the rehabilitation of memory impairment are now starting to emerge, although questions remain about which specific interventions and which specific patient characteristics might be associated with the best outcomes.

Cognitive rehabilitation approaches for memory impairment may be divided into restorative and compensatory approaches. Restorative approaches aim to

improve memory functioning through repeated memory exercises and drills, whereas compensatory approaches involve the use of strategies to circumvent memory problems, without aiming to improve memory functioning per se. Compensatory approaches may be further subdivided into internal aids (for example training in organizational strategies, rehearsal, visual imagery or mnemonics) and external aids (for example the use of diaries or electronic devices to support memory functioning). External memory aids may range from relatively simple paper-based aids such as lists or schedules up to complex technological memory aids (Kapur, Glisky & Wilson, 2004; Wilson & Kapur, 2009), and are particularly well suited to support prospective memory. As they have functional goals, they are key to the aims of the rehabilitation process.

Unfortunately there is little evidence that cognitive remediation is able to restore memory functioning once the initial period of spontaneous recovery is over (Cicerone et al., 2000; Kapur & Graham, 2002; Ptak, der Linden & Schnider 2010; Wilson 2005). However there is evidence that functional improvements in memory may be achieved through the use of compensatory strategies. Cicerone et al. (2011), in their most recent review, recommend the use of compensatory strategies (including notebooks and diaries) for mild memory impairment as a practice standard, and the use of externally directed assistive devices (such as pagers and voice organisers) for moderate to severe memory problems as a practice guideline. Similar conclusions about the effectiveness of external aids to compensate for functional memory problems have been reached in systematic reviews by Cappa et al. (2005), Rees et al. (2007) and Piras, Borela, Incoccia & Carlesimo (2011). However due to their wide scope

(most deal with cognitive rehabilitation as a whole), these reviews only provide very limited detail about studies concerned with the evaluation of external memory aids.

Sohlberg et al. (2007) are the only group to have systematically reviewed the literature specifically relating to the use of external memory aids, analysing 21 studies published up to 2003. They found that every study in their analysis described improved functioning on memory related activities in association with the implementation of external aids. Although the quality of the studies was insufficient to support a practice standard, they reiterated previous recommendations that the use of external memory aids should be considered a practice guideline for individuals with brain injury. However they noted that the lack of specificity of issues related to candidacy, selection of aids, training and a lack of evaluation of generalised and continued use of aids prevented the formulation of more detailed recommendations.

External memory aids are clearly important in the rehabilitation of memory impairment. However recent systematic reviews of cognitive rehabilitation as a whole have not described the literature on external aids in detail. Furthermore, the most recent review specifically addressing external aids (Sohlberg et al., 2007), only reviewed papers up to 2003. (Recent reviews of assistive technology by de Joode, van Heugten, Ferhey & van Boxtel, 2010, and Gillespie, Best & O'Neill, 2012, were not restricted to memory aids and did not include non-electronic aids). The aim of the present review was therefore to update and evaluate in detail the evidence for the use of external aids in the cognitive

rehabilitation of memory impairment. Following Cicerone et al. (2000, 2005, 2011) the review was concerned with memory impairments resulting from TBI and stroke, because these are the most prevalent forms of acquired brain injury requiring rehabilitation (Royal College of Physicians and British Society of Rehabilitation Medicine, 2003). In particular, the review aimed to evaluate in detail the evidence concerning which external aids, which training procedures, and which patient characteristics might be associated with the best outcomes.

## 2. METHOD

The inclusion criteria for the present review were as follows:

- 1) Articles concerned with rehabilitation of memory impairment
- 2) Articles reporting an intervention involving an external memory aid (or if a combination of interventions were used, where results relating to the external memory aid could be extracted)
- 3) Articles where the main participant diagnoses were TBI or stroke (other diagnoses were included when these were the minority of participants)
- 4) Articles involving adult participants.

Identification of the relevant literature was carried out in three stages. First, reference lists from the systematic reviews of Cicerone and colleagues (Cicerone et al. 2000; 2005; 2011) were searched to identify articles describing external aids for memory rehabilitation published up to 2008. This yielded 23 articles.

Second, in order to identify articles published from 2008 to present, MEDLINE, PsycINFO and CINAHL-Plus were searched from 2008 to March 2012 using the following strategy:

- 1) Subject Headings: Memory OR Memory Disorders OR Amnesia  
OR  
Keyword: memory

AND

2) Subject Headings: Rehabilitation OR Cognitive Rehabilitation OR  
Neuropsychological Rehabilitation or Neurorehabilitation

OR

Keywords: rehabilitat\* or remediat\* or compensat\*

AND

3) Subject Headings: Brain Injuries OR Head Injuries OR Traumatic Brain  
Injury OR Cerebrovascular Disorders

OR

Keywords: brain inj\* OR head inj\* OR stroke OR vascular

Searches were conducted individually for each database, as available subject headings varied between databases. Searches were limited to English language journal articles with human subjects. Results were then combined and de-duplicated. This resulted in 410 different articles. The abstracts or complete reports were then reviewed to identify those that met the inclusion criteria. This yielded 9 articles published between 2008 and March 2012.

Finally, the reference lists of relevant articles were scanned for additional studies not identified in the Cicerone et al. reviews or in the database search. This yielded 7 additional articles.

In total 39 articles were included in the review.

### **2.1. Quality Assessment:**

The level of evidence was assessed using the criteria of Cicerone et al. (2000, 2005, 2011). These are based on previously established criteria for the development of evidence-based clinical practice parameters (American Association of Neurologic Surgeons, 1995; Woolf, 1992) and similar systems have been widely used in systematic reviews evaluating the effectiveness of cognitive rehabilitation (Cicerone et al., 2000, 2005, 2011; Cappa et al., 2005; de Joode et al., 2010; Sohlberg et al., 2008). Three levels of evidence were established:

Class 1 studies: Well designed, prospective, randomised controlled trials. Prospective designs with “quasi-randomised” assignment to conditions, such as prospective assignment of participants to alternating conditions, were designated class 1a studies.

Class 2 studies: Prospective nonrandomised cohort studies; retrospective nonrandomised case control studies, or clinical series with well designed controls that permitted between-subjects comparisons of treatment conditions, such as multiple baseline across subjects.

Class 3 studies: Clinical series without concurrent controls, or studies with results from one or more single cases.

Of the 39 studies evaluated, 9 were class 1 (including 5 class 1a studies), 2 were class 2 and 28 were class 3.

## **2.2. Abstraction of information:**

Articles were reviewed and the following information was abstracted:

*Participant characteristics:* Number of participants, aetiology, time post-injury, severity of memory impairment, presence of any other cognitive impairment.

*Intervention characteristics:* Type of memory aid, nature and length of training and intervention, aim or target function of the intervention.

*Measurement characteristics:* Main outcome measures, any assessment of quality of life or well-being, whether the results were subject to statistical analysis.

*Results:* Main results, results relating to quality of life or well-being, results at follow-up, additional comments or methodological concerns.

## **3. RESULTS**

### **3.1 Paper-based external aids:**

12 studies evaluated paper-based external aids, for example diaries or memory notebooks. Three studies reported class 1 evidence, and the remaining nine studies were class 3. The key features of these studies are presented in Tables 1 (participant and intervention characteristics) and 2 (measurement characteristics and results).

**Table 1:**

Articles evaluating paper-based aids: Participant and intervention characteristics. NR = Not reported.

Author	Class	N	Aetiology	Time postinjury	Severity of memory impairment (and how categorised)	Other cognitive impairment?	Type of memory aid (and control / comparison group)	Length of training / intervention	Target Function
Owensworth & McFarland (1999)	1	20	15 TBI, 2 tumour, 2 infection, 1 stroke	4-37 yrs	Normal – Severe (RBMT)	NR	Diary cf. Diary + Self-Instructional Training	Training delivered by letter and 1 telephone call. Outcomes monitored over 4 weeks of use.	Use of diary; Reduction of everyday memory problems and associated distress
Schmitter-Edgecombe et al (1995)	1	8	TBI	> 24 mths	Majority had normal memory functioning (only 1 participant in each group was impaired on WMS / RBMT), although all scored < 89 on at least one subtest of WMS	NR	Memory Notebook (+ alarm) cf. Supportive Therapy	16 sessions group-based training (8 weeks)	Improvement on lab based memory measures and reduction of everyday memory failures and associated distress
Bergquist et al (2009)	1a	14	TBI	> 1 yr	Normal – Extremely Low (RBANS memory indices). All had z score of -1.0 or lower on one memory subtest of the RBANS.	NR	Memory notebook (Sohlberg & Mateer training program cf. no specific diary training)	30 online sessions in each condition	Improvement in memory functioning and related low mood, increased use of compensatory strategies and community integration.
Burke et al (1994)	3	1	TBI	NR	NR (difficulty remembering prior events and future plans, “intermittent” capacity for recall)	Impulse control, aggression, social judgement, attention/concentration, insight	Memory Book (Case study, no control)	Self awareness training followed by diary training. Length of training NR but “extensive”	Use of journal and improved memory functioning
Donaghy & Williams (1998)	3	2	1 stroke, 1 tumour	5 mths	Severe (< 0.1 %ile on memory measures)		Memory Journal System cf. Baseline	5-stage training program. S1 took 9 weeks (27 x 30 min sessions). Training failed with S2.	General memory compensation (but only prospective memory assessed).
Fowler et al (1972)	3	1	TBI	11 mths	“Severe memory deficit” (no tests reported)	NR	Printed schedule of daily activities (+ alarm) cf. Baseline	Training / Intervention program: 15 weeks.	Prospective memory

Author	Class	N	Aetiology	Time postinjury	Severity of memory impairment (and how categorised)	Other cognitive impairment?	Type of memory aid (and control / comparison group)	Length of training / intervention	Target Function
Kime et al (1996)	3	1	TBI	20 mths	Severe (immediate and delayed recall and recognition measures)	NR	Datebook (+ alarm) (Case study, no control)	Training: Took > 2 months to achieve independence.	Use of datebook
McKerracher et al (2005)	3	1	TBI	1 yr	Moderate (RBMT)	Language, attention, concentration, planning,	Memory notebook (Sohlberg & Mateer version cf. Donaghy & Williams version)	Training: 5 x 10 min sessions across 1 day. Notebooks assessed across 4x2 week intervention periods (ABAB design).	Prospective memory
Sohlberg & Mateer (1989)	3	1	TBI	NR	Severe (WMS and RAVLT)	Executive, attention, visuo-spatial processing deficits	Memory notebook. (Case study, no control).	4 stage training program that took 6 months	Use of notebook
Squires et al (1996)	3	1	Stroke	8 mths	Severe (WMS, ROCFT, RAVLT, RMT,	Executive	Memory notebook cf. Baseline	2 stage training program: 10 sessions "acquisition", 8 sessions "application"	Reduction of repetitive questioning
Zencius et al (1990)	3	6	TBI	6 yrs, 8 yrs, NR for 4 patients	No information on memory impairment reported	Executive	Memory notebook cf. 3 internal memory strategies (written rehearsal, verbal rehearsal, acronym formation) and no intervention	Training: prompted to enter information into notebook (no training to use independently). Outcome evaluated over 2 trials per condition	New learning
Zencius et al (1991)	3	4	TBI	NR	No information on memory impairment reported	Probable frontal / executive impairments in 1 patient with reported behavioural difficulties	Memory notebook cf. Baseline	Training: prompted to enter information into notebook (no training to use independently). Outcome evaluated over 5-9 days	Prospective memory

**Table 2:***Articles evaluating paper-based aids: Measurement characteristics and results*

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Owensworth & McFarland (1999)	1) No. diary entries 2) Daily memory checklist of commonly experienced memory problems (self-rating) 3) Ratings of helpfulness of strategy use (self-rating)	1) Distress ratings associated with daily memory failures 2) Weekly mood scale	F tests and t tests	1) No difference in overall no. diary entries between diary only (DO) and Diary + Self Instructional Training (DSIT) groups, but DSIT group showed better maintenance of no. entries over 4 week treatment period. 2) Sig. reduction in memory problems during treatment cf. baseline. No difference in memory problem score between DO and DSIT groups, but DSIT group showed greater reduction in memory problem score during treatment. 3) Both groups rated strategies as more helpful in treatment than baseline. DSIT group showed greater increase in helpfulness ratings.	1) Distress was reduced in both groups, no differential effect of training. 2) Reductions in Depression-Dejection, Fatigue-Inertia and Confusion-Bewilderment in both groups, with a greater decrease in confusion - bewilderment in DSIT group.	None	Both groups showed a sharp decrease in diary entries after week 1 and continuing reduction in entries to week 4.
Schmitter-Edgecombe et al (1995)	1) Laboratory-based recall tests (Logical Memory & Visual Reproduction, WMS-R) 2) Laboratory-based everyday memory tests (RBMT, modified to allow note-taking during administration) 3) Retrospective report of everyday memory failures (EMF) using Everyday Memory Questionnaire (Sunderland et al 1983) - average of participant and carer rating 4) Observed reports of EMFs - daily record of EMQ items for 7 days - average of participant and carer rating.	Symptom distress rated using Global Severity Index from Symptom Checklist 90 - Revised (Derogatis, 1980)	F tests	Conservative analyses: Those in notebook group had significantly fewer observed EMFs post-treatment than those in supportive therapy group.  Less conservative analyses: Observed EMFs significantly decreased pre-treatment to post-treatment in notebook group. Retrospective report of EMFs significantly decreased in supportive therapy group.  No differences on any lab-based measures	No significant reduction in symptom distress in either group	6 month follow-up.  Conservative analyses: No group differences.  Less conservative analyses: Retrospective and observed EMFs significantly reduced in notebook group at 6 month follow up  3 Ss reported continued use of notebook at follow up.	

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Bergquist et al (2009)	1) Memory scale of Neurobehavioural Functioning Inventory (NFI, completed by patient and family member) 2) Compensation Techniques Questionnaire items related to calendar use (completed by patient).	1) Mood scale of NFI (completed by patient and family member) 2) Community Integration Questionnaire	Non parametric analysis of difference scores from beginning to end of each condition	No significant differences between training and no training condition. But across entire 60 session intervention there was a significant improvement in family ratings of memory problems, and in patient ratings of use of compensatory techniques.	Significant improvement in family ratings of mood across entire 60 session intervention (no differences between training and no training condition). No sig. results on Community Integration Questionnaire between conditions or over whole 60 session intervention	None	Differences between the training conditions may have been masked by crossover design.  64% of participants who completed the program were already using a compensatory aid prior to study, compared to only 17% of those who dropped out – may indicate that online delivery of rehabilitation programs is more suited to a higher functioning group, or those already oriented to using aids.
Burke et al (1994)	Anecdotal	None	None	After extensive training, participant reported to review his journal independently each evening, and to be more organised, less overloaded with information, less confused and more receptive to feedback from others.	N/A	None	Anecdotal case report: no data.
Donaghy & Williams (1998)	Pre- and post-intervention performance on 10 prospective memory tasks to be carried out across a 5 day period, and anecdotal report.	Functional Assessment Measure (FAM)	None	Patient 1: 6/10 prospective memory tasks completed at baseline, 10/10 after memory journal training. Anecdotally reported to be 90-100% successful in recording medications, and making greater number of independent entries in diary (from 18 per week at baseline to 42 post training) No change on psychometric measures of memory.  Patient 2: 2/10 prospective memory tasks completed at baseline. Journal training failed. 2/10 prospective memory tasks completed at discharge	Patient 1: FAM improved from 4 to 5  Patient 2: no change in FAM rating (3)	None	Attributed failure of memory journal training in patient 2 to reduced awareness of memory deficit.

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Fowler et al (1972)	Attendance at therapy appointments	None	None	Baseline: anecdotal report that patient never attended appointments unless he was reminded. Weeks 1 and 2 (schedule + timer): patient attended 42/47 apps; Weeks 3+4 timer was phased out and schedule was used alone: patient attended 40/42 apps Weeks 5 onwards: patient spontaneously obtained his own appointment book and started to use this independently.	N/A	None	
Kime et al (1996)	1) Percentage compliance checking datebook when cued by chime 2) No. entries under action record in datebook 3) No. cross references in datebook 4) No. separate entries in monthly calendar. Measured first 21 days of treatment, last 21 days of treatment (after 64 days in program) and 3 follow ups 5) Standardised measures of memory: WMS, ROCFT, CVLT, CBPMT	None	None	1) Over the 2 month training program compliance checking the datebook in response to the chime increased from 47.6% with therapist prompting, to 100% with no prompting. 2) Action records increased from 4.86 entries per day to 8.05 entries per day, but still required prompting from therapist or family. 3) Cross references reduced from 0.57 per day to 0.33 per day, but still required prompting from therapist or family. 4) Use of monthly calendar declined throughout training (but see follow up data). 5) Standardised measures: No change on WMS, ROCFT or CVLT. CBPMT increased from 40% on admission to 90% on discharge due to note-taking strategy.	N/A	Follow up of diary use 4, 7 and 13 months post-discharge.  Checking, action records and cross referencing were all maintained throughout follow up. Patient also spontaneously started to use the calendar section of notebook again after discharge and at 13 month follow up was making 40 entries per month.	Authors comment on importance of being part of a comprehensive rehabilitation program including MDT working and psychotherapy.

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
McKerracher et al (2005)	Performance on 5 prospective memory tasks per week	Beck Depression Inventory	None	Significantly better performance with the Donaghy & Williams diary (15/20 tasks completed) than with the Sohlberg & Mateer diary (1/20 tasks completed)  RBMT profile score reduced from 11 to 10 (both moderate memory impairment)	Increase on BDI over the course of the study (39-45) due to adverse life events, but no significant change during diary use (scores of 38/39/40).	None	Superior results for Donaghy & Williams diary were attributed to not having to move between sections.  Training period was much shorter than original Sohlberg & Mateer or Donaghy & Williams studies.  One of the only papers to comment on anxiety and low mood and the effect this may have on rehabilitation.
Sohlberg & Mateer (1989)	Anecdotal	None	None	Successful use of book after 6 months and maintained at 6 month follow up with significantly greater independence.  Standardised testing showed mild-moderate gains in attention and delayed recall after distraction (not using book), still profound limitations in memory and new learning	At study entry patient required 24 hour support in a group home. At follow up patient was living alone with 1 hr assistance, managing sheltered employment, and referred for paid employment training.	Consistent use of memory notebook 6 mths after discharge.	Significant "real-world" outcome.  But no data on which aspects of memory functioning were most improved, or any ongoing problems.  Not reported if use of memory notebook at follow up was independent or reliant on cues.
Squires et al (1996)	Daily incidences of repetitive questioning (recorded by wife)	None	t-tests pre-post	Significant reduction in repetitive questioning after diary training  Some improvement in visual memory on WMS. Verbal and delayed indices remained the same. No improvement on other standardised tests.	Carer strain reported to be reduced.	Reported to still be using notebook on "subsequent unannounced visits" but time lapse not reported.	Patient remained reliant on wife to make entries in notebook

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Zencius et al (1990)	Recall of 6 items of information from 3 job adverts (employer, job title and level of experience / education needed)	None	None	1 patient performed well at baseline and across all interventions. Others benefited most from notebook.  Group mean recall: Baseline: 2.2/6 components recalled. Written rehearsal 2.0 / 6 components Verbal rehearsal 3.0/ 6 components. Acronym formation 3.3 / 6 components Notebook 5.9 / 6 components	N/A	None	Only paper to directly compare to external to internal compensatory strategies.  But potential confounds due to order effects (conditions not adequately counterbalanced) and repeated recall of the same information. (Details of procedure insufficient to allow evaluation)
Zencius et al (1991)	No. components of homework assignments completed correctly (each homework assignment consisted of meeting a named person at a certain place and time and turning in a written assignment)	None	None	Improvement in prospective memory performance in all participants with use of memory notebook. At baseline average no. components completed for each participant was 1, 1.2, 0 and 0. With memory notebook this improved to 3, 3, 2.8 and 1.5.	N/A	None	Smallest improvement was in patient with executive / behavioural difficulties.  Some concerns about reporting of data (query number of trials per participant and inconsistent reporting of performance for participant 3)

### *3.1.1. Participant characteristics:*

In all, 60 participants were studied, the majority of whom were TBI patients (n = 52; other diagnoses were stroke n=3, tumour n=3 and infection n = 2). Participants varied in time post-injury, from 5 months to 37 years, and this information was not reported in three studies. There was a wide range in severity of memory impairment, with some participants having severe impairments, but others falling into the normal range on standardised memory testing. In most cases severity of impairment was categorised according to standardised measures such as the Rivermead Behavioural Memory Test (RBMT) or the Wechsler Memory Scale (WMS). In one case standardised measures were not reported but a clinical description of memory impairment was provided (Burke, Danick & Dugin, 1994). However in two cases there was no mention at all of memory impairment in the description of the participants (Zencius, Wesolowski, & Burke, 1990; Zencius, Wesolowski, Krankowski & Burke, 1991). Only half of the studies specified whether their participants also suffered from other cognitive impairments in addition to memory impairment. Of those that provided this information, all had additional executive impairment.

### *3.1.2. Intervention characteristics:*

Eleven studies evaluated the use of a diary or “memory notebook”. One study evaluated the use of a simple printed schedule of daily activities (Fowler, Hart & Sheehan, 1972). Three studies used an alarm to alert participants to consult their diary or schedule (Schmitter-Edgecombe, Fahy, Whelan & Long, 1995; Fowler et al., 1972; Kime, Lamb & Wilson, 1996). Most studies compared use of

the paper aid to baseline or to a “no intervention” condition. One study compared two methods of diary training (Ownsworth & McFarland, 1999), one compared diary training to supportive therapy (Schmitter-Edgecombe et al., 1995), and one compared two types of memory notebook (McKerracher et al., 2005). Only one study directly compared the use of an external aid to alternative memory rehabilitation approaches (Zencius et al., 1990). This study compared use of a memory notebook to three internal memory strategies: written rehearsal, verbal rehearsal and acronym formation.

Length of training varied widely between studies, from one day (McKerracher, Powell & Oyebode, 2005) to six months (Sohlberg & Mateer, 1989). The components of the training programmes also varied, with some authors offering detailed protocols for diary training (Burke et al., 1994; Donaghy & Williams, 1998; Sohlberg & Mateer, 1989). Others offered key additions to traditional training, for example “self-instructional training” (Ownsworth & McFarland, 1999) or “self-awareness training” (Burke et al., 1994). Most studies used traditional one-on-one therapist-led training, but one study used group-based training (Schmitter-Edgecombe et al., 1995) and two studies used “distance” training: Bergquist et al. (2009) evaluated the provision of online training using Instant Messenger, and Ownsworth & McFarland (1999) delivered their instructions by letter and a follow up telephone call. The aims of training also varied. Most studies aimed to teach participants to use their external aid independently. However in the two studies by Zencius and colleagues (Zencius et al., 1990, 1991) participants were prompted to enter the information into

their notebooks in the presence of the experimenter, and no attempt was made to teach participants to use their aids independently.

The aims of each study varied, two simply aimed to establish use of the external aid (Kime et al., 1996; Sohlberg & Mateer, 1989), three targeted prospective memory (Fowler et al., 1972; McKerracher et al., 2005; Zencius et al., 1991), one targeted reduction of repetitive questioning (Squires, Hunkin & Parkin, 1996), one targeted new learning (Zencius et al., 1990), and five aimed to more generally improve memory functioning and related distress (Ownsworth & McFarland, 1999; Schmitter-Edgecombe et al., 1995; Bergquist et al., 2009; Burke et al., 1994; Donaghy & Williams, 1998).

### *3.1.3. Measurement Characteristics:*

The most frequent outcome measures were performance on prospective memory tasks (four studies), measures relating to use of the external aid (three studies) and checklists of everyday memory failures (three studies). Of the studies that used this type of checklist, two employed self-ratings (Ownsworth & McFarland, 1999; Bergquist et al., 2009), and two employed ratings derived from both self- and significant other-ratings (Schmitter-Edgecombe et al., 1995; Bergquist et al., 2009). One study reported behavioural ratings (of repetitive questioning, Squires et al., 1996) and one study reported recall of newly learned information (Zencius et al., 1990). Six studies included standardised tests of memory amongst the outcome measures (Schmitter-Edgecombe et al., 1995, Donaghy & Williams, 1998, Kime et al., 1996; McKerracher et al., 2005, Sohlberg & Mateer, 1989; Squires et al., 1996). Only one study included participant

ratings of the helpfulness of the aid (Ownsworth & McFarland, 1999). Two single case studies did not employ formal outcome measures, instead presenting anecdotal reports of the participants' response to diary training (Burke et al. 1994, Sohlberg & Mateer, 1989).

Only five studies included measures assessing quality of life or well being. Two studies evaluated the impact of their interventions on symptom distress (Ownsworth & McFarland, 1999, Schmitter-Edgecombe et al., 1995), three studies evaluated impact on mood ratings (Ownsworth & McFarland, 1999, Bergquist et al., 2009, McKerracher et al., 2005), one study evaluated impact on community integration (Bergquist et al., 2009) and one study evaluated impact on cognitive and psychosocial disability (FAM, Donaghy & Williams, 1998).

Only four of the twelve studies conducted statistical analysis of their results: these were the three class 1 studies (Bergquist et al., 2009; Ownsworth & McFarland, 1999; Schmitter-Edgecombe et al., 1995) and one class 3 study (Squires et al., 1996) which employed pre- and post- comparisons.

#### *3.1.4. Results:*

All twelve studies reported positive outcomes associated with use of an external aid, strongly supporting the use of paper-based external aids in the rehabilitation of memory impairment. However in some cases there were additional factors or methodological concerns which affected interpretation of the results.

*Class 1 studies:*

A class 1 randomised controlled trial by Ownsworth & McFarland (1999) reported a significant reduction in memory problems whilst using a diary compared to baseline. Moreover they reported that particular benefit was associated with the addition of “Self instructional training” (an executive strategy encouraging identification of a goal, selection of a strategy, implementation of the strategy, and checking of the outcome) to ordinary diary training. They reported that self instructional training was associated with better maintenance of diary use and greater reduction of memory problems than diary training alone. However both groups showed a sharp decrease in diary use from weeks 1-4 of the intervention, casting some doubt on the success of the intervention as a whole. It was unclear whether the diary was truly adopted or maintained in either group, and this may have been related to a much shorter training period than that reported in other studies.

Another class 1 study by Schmitter-Edgecombe et al. (1995) reported that participants who had undergone 16 sessions of group memory notebook training had significantly fewer observed everyday memory failures post-treatment than those who had undergone 16 sessions of group supportive therapy. Unfortunately this group difference was not maintained at 6 month follow-up (although less conservative analyses did indicate that everyday memory failures in the notebook group remained significantly lower than baseline observations).

Bergquist et al. (2009) set out to evaluate the outcome of 30 sessions of memory notebook training compared to 30 sessions involving no specific diary training, in a randomised crossover trial (class 1a study). They found no significant differences between the training and no training conditions. However differences between the conditions may have been masked by the crossover design. Importantly, they did report that over the entire diary intervention (consisting of both types of training), there was a significant improvement in family ratings of memory problems, and in patient ratings of use of compensatory techniques, demonstrating positive results for the external aid in general.

*Class 3 studies:*

Amongst the class 3 studies, successful outcomes associated with the use of paper-based external aids included improvement in prospective memory functioning (Donaghy & Williams, 1998; Fowler et al., 1972, Zencius et al., 1991), successful independent use of a diary (Burke et al. 1994; Donaghy & William, 1998; Fowler et al., 1972; Sohlberg & Mateer, 1989), and reduction in repetitive questioning (Squires et al., 1996). The results of McKerracher et al. (2005) indicated that a simplified diary (modelled on that of Donaghy & Williams, 1998) may be more successful than a more complex version (Sohlberg & Mateer, 1989).

However there were also some negative results. Donaghy & Williams (1998) reported that diary training failed in one of their participants, and this was attributed to reduced awareness of deficit. It was also notable in the study by

Zencius et al. (1991), that the patient who showed least benefit from their memory notebook intervention was the patient whose description indicated executive difficulties.

In general there was no significant improvement on standardised tests of memory (Schmitter-Edgecombe et al., 1995, Donaghy & Williams, 1998, McKerracher et al., 2005, Sohlberg & Mateer, 1989; Squires et al., 1996), confirming that external aids are a compensatory rather than a restorative approach. Kime et al. (1996) reported an increase in scores on the Cambridge Behavioural Prospective Memory Test (CBPMT), but this was due to the participant adopting a note-taking strategy.

In the only paper to directly compare external memory aids to alternative memory rehabilitation strategies, Zencius et al. (1990) reported superior recall of information using a memory notebook compared to three internal strategies (written rehearsal, verbal rehearsal or acronym formation). However due to potential confounds in their procedure (which appeared to involve repeated recall of the same information, and in which recall using the notebook always occurred after at least 6 previous recall trials), the level of evidence is less strong than would be desirable.

#### *Quality of Life / Well-being:*

Results relating to the impact of paper-based external aids on quality of life or well-being were mixed. Ownsworth & McFarland (1999) reported a significant reduction in distress ratings associated with everyday memory failures, in both

their “Diary Only” (DO) and “Diary + Self Instructional Training” (DSIT) groups. They also reported reductions in Depression-Dejection, Fatigue-Inertia and Confusion-Bewilderment in both groups, with a greater decrease in Confusion-Bewilderment in the DSIT group. Bergquist et al. (2009) reported a significant improvement in family ratings of mood, and Donaghy & Williams (1989) reported a small improvement in FAM rating for one of their participants. Anecdotal reports also described increased independence (Sohlberg & Mateer, 1989) and reduced carer strain (Squires et al., 1996) associated with the use of paper-based external aids.

However Schmitter-Edgecombe et al. (1995), despite reductions in everyday memory failures, found no reduction in symptom distress in either their Memory Notebook or Supportive Therapy conditions. Similarly, McKerracher et al. (2005) reported no improvement in BDI scores during diary use, and Bergquist et al. (2009) found no significant improvement on their Community Integration measure.

*Follow-up:*

Only four of the twelve studies reported follow-up data, but these were largely positive. Schmitter-Edgecombe et al. (1995) found that although group differences between the memory notebook and supportive therapy conditions were not maintained at 6 month follow up, everyday memory failures in the notebook group remained significantly lower than at baseline. Three of their eight participants reported that they were still using the notebook at this time. Kime et al. (1996) reported that diary use in their single case was maintained at

4, 7 and 13 months post-discharge, Sohlberg & Mateer (1989) reported that their patient had maintained consistent use of her memory notebook 6 months after discharge, and Squires et al. (1996) reported that their patient was still using his notebook on “subsequent unannounced visits”, although he was reliant on his wife to make the entries for him. It is notable that the training in all these cases was fairly lengthy, lasting between 8 weeks and 6 months.

***Summary: Paper-based aids***

*Three class 1 studies and nine class 3 studies reported positive results, with negative findings in a small number of participants attributed to executive difficulties. Findings related to quality of life were mixed. Follow-up was reported in four studies that had employed longer training periods, with generally positive results.*

**3.2 Electronic external aids:**

27 studies evaluated the use of electronic external aids. Six studies reported class 1 evidence, two studies were class 2, and the remaining nineteen were class 3. The key features of these studies are presented in Tables 3 (participant and intervention characteristics) and 4 (measurement characteristics and results).

**Table 3:***Articles evaluating electronic aids: Participant and intervention characteristics. NR = Not reported*

Author	Class	N	Aetiology	Time postinjury	Severity of memory impairment (and how categorised)	Other cognitive impairment?	Type of memory aid (and control / comparison group)	Length of training / intervention	Target Function
Fish et al (2008)	1a	36	Stroke	Mean 3.3 yrs (min 6 mths)	NR (but in original study RBMT group mean was moderately impaired, with range normal – severely impaired)	NR (but inclusion criterion was memory and / or planning problems)	Paging system cf. Baseline (ABA)	Training: Short trial to see if participants could read message and press response button. Outcome assessed over 7 weeks with pager.	Prospective Memory
Wilson et al (2005)	1a	63	TBI	Mean 5.3 yrs (min 6 mths)	NR (but in original study RBMT group mean was moderately impaired, with range normal – severely impaired)	NR (but inclusion criterion was memory and / or planning problems)	Paging system cf. Baseline (ABA)	Training: Short trial to see if participants could read message and press response button. Outcome assessed over 7 weeks with pager.	Prospective Memory
Wilson et al (1997)	2	15	10 TBI, 3 stroke, 1 tumour, 1 colloidal cyst	6mths - 13 yrs	Mild - severe (RBMT)	NR	Neuropage cf. Baseline (ABA)	No training. Outcome assessed over 12 weeks with pager.	Prospective Memory
Hersh & Treadgold (1994)	3	16	TBI	3-12 yrs	Mild to severe (measure NR)	NR	Study 1: Neuropage cf. Baseline Study 2: Neuropage cf. Log sheet Baseline (ABA). TBI cf. Healthy Control.	Training: 2 hrs to learn and 2-3 days to proficiency for programmer. A few minutes to learn to use receiver. Outcome assessed over 1 week with pager.	Prospective Memory
Kirsch et al (2004)	3	1	TBI	NR	Borderline - Extremely Low (WMS)	NR - query some executive impairment	Pager cf. Baseline (ABA)	No Training. Outcome assessed over 9 weeks with pager.	Prospective Memory
Wilson et al (1999)	3	1	TBI	7 yrs	Severe (RBMT)	No	Neuropage cf. Baseline (ABA)	1 training session. Outcome assessed over 7 weeks with pager.	Prospective Memory

Author	Class	N	Aetiology	Time postinjury	Severity of memory impairment (and how categorised)	Other cognitive impairment?	Type of memory aid (and control / comparison group)	Length of training / intervention	Target Function
Dowds et al (2011)	1a	36	TBI	NR	Normal – severely impaired (WMS).	NR	2 types of Personal Digital Assistant cf. Paper Planner and Baseline	Brief training (instructed to input assignments). Outcome assessed over 2 1-week periods with device (ABCDABCD design).	Prospective memory
Thone-Otto & Walther (2003)	2	12	6 TBI, 3 stroke, 1 systemic lupus erythematosus, 2 “other neurological disease”	> 28 mths	Normal - moderately severe (WMS)	NR	Personal Digital Assistant and Mobile Phone with agenda function cf. Baseline	Training: Up to 5 x 1 hr sessions. Outcomes assessed over 2 week intervention periods with each device.	Prospective Memory
Gentry et al (2008)	3	23	TBI	1-34 yrs	Poor – Impaired (RBMT-E)	NR	Personal Digital Assistant cf. Baseline	3-6 90 min training sessions. Outcome assessed over 8 weeks with PDA.	Everyday memory performance / Participation in everyday life tasks
Giles & Shore (1989)	3	1	Stroke	18 mths	Moderate (WMS)	No	Personal Digital Assistant cf. Pocket Diary and No Aid.	Training: 4 hrs individual training, 6 hrs practice with relatives, 1 further month of use until proficient. Data collected over 2 day period.	Prospective memory
Kim et al (1999)	3	1	TBI	2 mths	NR	Executive dysfunction, cognitive-linguistic deficits, attention and organisation impairments	Personal Digital Assistant (Case report no control)	No training. Device programmed by staff.	Prospective Memory
Wright et al (2001)	3	12	Predominantly TBI (other aetiologies not reported)	2-12 yrs	4 Severe, 6 Slight impairment, 2 Average (RBMT)	5 had executive impairments	2 types of Personal Digital Assistant (no control)	Training: 1 session and manual. Outcome assessed over 8/10 weeks with each device.	Use of aid / Prospective Memory

Author	Class	N	Aetiology	Time postinjury	Severity of memory impairment (and how categorised)	Other cognitive impairment?	Type of memory aid (and control / comparison group)	Length of training / intervention	Target Function
Hart et al (2002)	3	10	TBI	3 mth - 18 yrs	Severe memory deficits affecting functioning (clinical opinion)	Numerous (including executive impairments)	Voice Organiser (cf. No Organiser)	Up to 3 training sessions. Outcome assessed after 1 week.	Memory for therapy goals
van den Broek et al (2000)	3	5	2 stroke, 1 TBI, 2 encephalitis	19-54 mths	Poor – Severely Impaired (RBMT)	NR	Voice Organiser cf. Baseline (ABA)	Training NR. Outcome assessed over 3 weeks with voice organiser.	Prospective memory
van Hulle & Hux (2003)	3	3	TBI	14 mths, 7 yrs 14 yrs	NR	2 had executive impairments	Digital Voice Recorder and Watch Alarm cf. Written Reminders	Training NR. Outcome assessed over max. 2 weeks with each aid.	Prospective memory
Yasuda et al (2002)	3	8	4 TBI, 3 stroke, 1 tumour	2-25 mths	Moderate-Severe (WMS)	Some had executive impairments	IC Voice Recorder cf. Baseline (ABA)	No training. Device programmed by experimenter. Outcome assessed over variable periods with device (1 week to 3 months).	Prospective memory
Culley & Evans (2010)	3	11	9 TBI, 2 anoxic brain injury	3 mths - 16 yrs	NR	NR	Mobile Phone (text message) cf. No Mobile Phone	No training. Outcome assessed after 1 week and 2 weeks with mobile phone.	Memory for therapy goals
Stapleton et al (2005)	3	5	TBI	5-26 yrs	1 Poor, 1 Moderate, 3 Severe (RBMT)	4 had severely impaired attention and comprehension speed, 3 had executive impairment	Mobile phone (reminder function) cf. Baseline (ABAB)	No training. Outcome assessed over 2 intervention periods with phone (7 weeks and 2 weeks in ABAB design)	Prospective memory
Wade & Troy (2001)	3	5	3 TBI, 2 stroke	1-15 yrs	4 Moderate, 1 Severe (RBMT)	All had executive impairment, 2 had language impairment and 1 had attention/concentration impairment.	Mobile phone (voice messages)cf. Baseline	No training. Outcome assessed after 12 weeks with mobile phone	Prospective memory

Author	Class	N	Aetiology	Time postinjury	Severity of memory impairment (and how categorised)	Other cognitive impairment?	Type of memory aid (and control / comparison group)	Length of training / intervention	Target Function
McDonald et al (2011)	1a	12	4 TBI, 4 stroke, 1 anoxic BI, 1 encephalitis, 1 toxic-metabolic encephalopathy, 1 AVM	15 - 231 mths	Normal - significant impairment (RBMT)	5 had executive impairment	Google online electronic calendar and linked text alerts sent to mobile phone cf. Standard Diary and Baseline	1 x 90 min training session for each aid. Outcomes evaluated over 5 week period with each aid.	Prospective Memory
Lemoncello et al (2011)	1a	23	16 TBI, 5 stroke, 1 anoxia, 1 tumour	> 1 yr	NR	Some executive difficulties	Television Assisted Prompting (audiovisual messages delivered to TV) cf. Usual Practice	No training. Outcome assessed over 2 x 2-week periods (ABAB)	Prospective memory
Kirsch et al (1992)	3	4	TBI	1-10 yrs	Immediate verbal and visual recall > 2D below mean (WMS)	Executive dysfunction in all	"Interactive Task Guidance" (cues delivered on a computer screen) cf. Written Instructions	Orientation provided in first trial of each condition. Outcome assessed over variable no. trials per subject.	Vocational task (cleaning bathroom and waiting room)
Brindley et al (2011)	3	1	TBI	7 yrs	NR	NR	SenseCam cf. CBT Automatic Thought Records and No Strategy	Training NR. Each method used at a single event.	Recall of anxiety related trigger events in CBT for anxiety
Shum et al (2011)	1	45	TBI	Mean 9 mths (minimum NR)	NR (but severe amnesia was an exclusion criteria)	NR	Diary or Organisational device. Compared 4 training conditions: 1) Self Awareness Training (SAT) + Compensatory Prospective Memory Training (CPMT), 2) SAT plus active control 3) active control plus CPMT, 4) active control only.	8 weekly sessions training	Prospective Memory

Author	Class	N	Aetiology	Time postinjury	Severity of memory impairment (and how categorised)	Other cognitive impairment?	Type of memory aid (and control / comparison group)	Length of training / intervention	Target Function
Fleming et al (2005)	3	3	TBI	2 mths, 4 mths, 12 mths	NR	NR	Diary or electronic organiser (patient choice) cf. Baseline	8 week training program.	Prospective Memory
Boman et al (2007)	3	8	6 TBI, 2 stroke	2-16 yrs	Poor - Moderate (RBMT)	Attention, working memory, problem solving.	Training apartment cf. Baseline	Training over initial 3 weeks in apartment (1-2 hrs, 4-5 times weekly). Stay of 4-6 months.	Everyday memory performance, Change in independent function and QOL
Boman et al (2010)	3	14	Stroke / TBI	2-41 mths	Normal - Moderate (RBMT)	NR	Training apartment (Day 1 cf. Day 4)	Training over initial 4 days in apartment. Stay of 5 days.	Ability to use aids.

**Table 4:**  
*Articles evaluating electronic aids: Measurement characteristics and results*

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Fish et al (2008)	Performance on 4-7 tasks per day selected with patient and carer (e.g. taking medication, meal preparation). Recorded by patient and carer daily in memory diary	None	Odds ratio for individual performance, non-parametric analysis for group comparisons	Group results: Significant improvement in completion of everyday tasks with pager, with performance returning to baseline when pager withdrawn.  Individual results: 33/36 patients showed a significant improvement with pager (2 improved but not significantly, one got worse). After removal 70% showed significant decrease in performance.	N/A	None	Return to baseline after withdrawal associated with executive impairment.
Wilson et al (2005)	Performance on 4-7 tasks per day selected with patient and carer (e.g. taking medication, meal preparation). Recorded by patient and carer daily in memory diary	None	Odds ratios for individual performance, chi square for group analyses	Group results: Significant improvements in completion of everyday tasks with pager. Also some maintenance of effect after withdrawal with significant decline in performance but not to baseline levels.  Individual results: 81% improved with pager (6% significantly worse with pager). After removal 46.67% showed significant decrease in performance. Better maintenance of effect was associated with better executive function (reported in Fish et al, 2008)	Reported increase in level of independence e.g. one participant used pager to manage business meetings.	None	7 week intervention appeared sufficient to establish a routine that could be maintained after withdrawal of pager.  Authors report unsuccessful interventions in cases where a) patient felt there was nothing wrong b) patient so dependent on others that they are unable to carry out any activities independently, and c) carers / relatives felt they should do the reminding rather than a pager.

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Wilson et al (1997)	Performance on 1-7 tasks per day selected with patient and carer.	None	Odds ratios	<p>Significant increase in tasks achieved (from 37.08% in baseline to 85.56% during treatment). Change was significant at group level and also for each individual.</p> <p>After removal of pager, 74.74% tasks achieved. Some individuals returned to baseline, others had almost no decline from treatment level.</p>	Anecdotal reports of increased independence, e.g. one patient able to return to college, another no longer needed full time carer.	None	Results indicated different responses to pager, with some participants maintaining benefits after removal of pager but others needing it in the longer term to maintain benefits.
Hersh & Treadgold (1994)	<p>Study 1: attendance at rehabilitation groups and personalised targets e.g. domestic chores, medication.</p> <p>Study 2: telephone calls to voice mail 3 times per day.</p>	None	<p>Study 1: None</p> <p>Study 2: F tests</p>	<p>Study 1: attendance at group in the 4 participants increased from 10% to 70%, 30% to 100%, 50% to 100% and 70% to 100%. On personalised targets, improvements ranged from 50% to 100%.</p> <p>Study 2: Significantly higher compliance with phonecalls and significantly better temporal accuracy with Neuropage than written log. Return to baseline when withdrawn.</p> <p>Performance of TBI patients with Neuropage did not differ from Healthy Controls.</p>	N/A	None	
Kirsch et al (2004)	Percentage of therapy appointments recorded in daily planner.	None	None	Performance increased from 22.38% of therapy appointments recorded at baseline, to 93.57% with pager. Performance returned to baseline after withdrawal.	N/A	None	

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Wilson et al (1999)	Performance on 7 target behaviours (e.g. preparing dinner, remembering keys) recorded by patient (with help from carer).	Caregiver Strain Index	None	Performance of targets increased from 48% at baseline to 87% with pager. After withdrawal, performance dropped to 70% (performance declined on 4 tasks but was maintained or further improved on 3).	Carer strain was significantly reduced with pager. Anecdotal report of increased independence and reduced care needs.	Pager returned to patient for extended trial: 80% of original targets that were still meaningful were achieved at 1 mth, 100% at 2 mths.	Number of pager messages required reduced as routines established.
Dowds et al (2011)	Call to voice mail 5 x per week plus 3 time related tasks, personalised to each participant, with completion reported by telephone call to research office	None	Negative binomial regression	Baseline 27% completion; Paper planner 26% completion; Microsoft PDA 38% completion; Palm PDA 56% completion  Both PDAS were significantly better than baseline, but Palm was significantly better than Microsoft.  Gender, age and performance on cognitive measures did not predict success rate.	N/A	None	Even the best rates of performance were still quite low at 56%.  Messages were input for participants, so performance did not depend on ability to master the device. Study did not evaluate how much training would be necessary to do this.

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Thone-Otto & Walther (2003)	1) 20 experimental tasks, 2) patient-recorded everyday forgotten intentions, 3) no. functions learnt on device, 5) no. intentions entered into device by patient, 6) satisfaction rating	None	Yes (test not reported)	No comparison of results from from PDA and mobile phone – data collapsed together.  Number of experimental tasks and everyday intentions forgotten reduced with memory aids cf. baseline, but difference did not reach significance.  Some participants more able to learn functions than others, and this group favoured the PDA over the mobile phone.  Ability to learn functions correlated with WMS scores.	N/A	None	Some concerns about data: Performance appears to be at ceiling even at baseline (mean forgotten experimental tasks 0.12%, and mean 0.36 forgotten intentions per day).  Only a subset of results are reported.  Everyday forgotten intentions was a self-report measure, and therefore potentially unreliable.  Both PDA and mobile phone were reported by participants to require too many steps to enter information, and to have keys that were too small.
Gentry et al (2008)	Rating of 5 deficits in everyday life related to memory impairment (e.g. forgetting appointments) as assessed by Canada Occupational Performance Measure (COPM, completed jointly by patient and carer)	Participation in everyday life tasks as assessed by Craig Handicap Assessment and Rating Technique - Revised (CHART-R, completed jointly by patient and carer)	Paired t tests, Repeated measures ANOVA	Significant improvement on COPM ratings of everyday performance related to memory impairment, and on satisfaction with this performance, 8 weeks after training.	Significant improvement on rating of cognitive independence, mobility and occupation scales (CHART-R) 8 weeks after training, but not on physical independence, social integration or economic self sufficiency scales	Outcomes assessed after 8 weeks of independent use, post training	All participants reported prior knowledge of computers for email and web, and also reported using some kind of aid prior to study (e.g. sticky notes or appointment calendars).  Although PDA showed positive effects over and above these, a positive outcome may also be reliant on pre-existing willingness / general orientation to using aids

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Giles & Shore (1989)	10 household chores to be completed over weekend at home – completion and time completed logged by patient	None	None	Baseline 0 tasks completed. With pocket diary 8/10 tasks performed, 6 on time. With PDA 9/10 tasks performed, all on time	N/A	Patient still using PDA effectively in everyday life 3 months after study	<p>Task completion and time of completion logged by patient which could be unreliable</p> <p>Superior performance with PDA over pocket diary attributed to alarm, but participant actually performed relatively well with diary given severity of baseline performance.</p> <p>Participant relatively high functioning other than memory deficit - IQ in normal range, insight into deficits and only mild difficulties in initiating behaviour.</p>
Kim et al (1999)	Anecdotal - attendance at therapy sessions and independently asking for medication	None	None	From first day with PDA, participant arrived on time to all therapy sessions and was able to ask for all medications on his schedule - 100% performance	N/A	None	
Wright et al (2001)	1) Use of aid 2) Self report of memory failures in “no-aid” phase that participants reported they would have used the PDA for	None	Yes - various	<p>1) Participants made approx. 3 entries per day and rated usefulness of PDA as 6.5/10.</p> <p>2) Only 3 people recorded forgetting things in “no aid” phase that they would have put into computer.</p> <p>No correlations between psychometric measures and no. of diary entries.</p>	N/A	None	<p>No objective assessment of impact on memory. Data could indicate that only 25% benefited from PDA, but may also reflect a problem with self report measure.</p> <p>5 participants dropped out (may have found it more difficult to use / less helpful than those reported)</p>

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Hart et al (2002)	Free and cued recall of 6 therapy goals - 3 recorded and played 3x a day on voice organiser, 3 unrecorded.	None	Friedman / Wilcoxon signed ranks tests	Significantly greater recall of recorded than non-recorded goals after 7 days. Clinician report that 69% of recorded goals were associated with progress in rehabilitation, cf 22% non-recorded goals.	NA	None	Even where voice organiser did not improve free recall it did have an impact on cued recall, so still has application for severe memory impairment.  One of few studies to evaluate an outcome other than prospective memory.  All participants reported liking the device and said they would use it again.
van den Broek et al (2000)	1) Passing message to relative after 9 hour delay. 2) 4 domestic chores to be carried out throughout week.	Positive and Negative Affect Schedule (PANAS)	None	1) All 5 participants showed improved performance on message passing with the voice organiser (mean increase from 2.4/24 to 18.2/24). 2) 4/5 participants showed improved performance on the domestic chore measure (mean increase from 3.8/12 to 10/12).  Most participants' performance returned to baseline after removal of aid, but performance was at least partially maintained in 2.	No change on PANAS.	None	

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
van Hulle & Hux (2003)	Independence in requesting medication from staff	None	None	<p>A different pattern was observed for each participant:</p> <p>P1: achieved 56% in first written reminder, 74% with watch, then achieved 4 days 100% performance in second phase with written reminders (voice recorder not employed).</p> <p>P2: achieved 3 days 100% performance in first written reminder phase (intervention discontinued, neither watch or voice organiser employed).</p> <p>P3: No systematic improvement with any aid.</p>	N/A	None	<p>Treatment was terminated when a participant showed 100% independent performance over 3-4 days, so not all conditions completed, and no assessment of maintenance beyond 3-4 days.</p> <p>Authors comment that responses to aids are unique and that interventions are best targeted to the individual.</p> <p>Failure to benefit from aids in P3 was attributed to lack of motivation to be independent</p>
Yasuda et al (2002)	Completion of daily task (diary writing, letter writing or physical exercise)	None	None	Voice recorder was effective for only 5/8 participants. Of these, 1 showed maintenance of effect after withdrawal, 1 showed reduced effect, 3 returned to baseline	N/A	None	<p>Variable length of treatment, some only had 1 week,</p> <p>Voice recorder had no effect in 3/8 patients – attributed to executive dysfunction and initiation problems in 2 cases, but reason for failure unclear in 3<sup>rd</sup>.</p>
Culley & Evans (2010)	Free and cued recall of 6 therapy goals – 3 sent by text message 3x a day, 3 unsend.	None	Wilcoxon signed ranks test and correlation effect sizes	Participants recalled significantly more therapy goals in text than no text condition, at 7 days and 14 days, and majority of improvement had occurred in 7 days.	N/A	None	Some participants reported that regular alerts also had a general orienting function, prompting orientation to time, taking stock of what they were doing, and goal oriented behaviour

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Stapleton et al (2005)	Performance on daily target behaviours selected with participant and carer. Performance recorded by carer (and also by participant in 2 cases)	None	None	3 participants showed no improvement, 2 participants showed improvement from around 55% at baseline to around 90% with mobile phone. Gains were maintained in 1 patient even when mobile phone was removed.	N/A	None	Those who did not improve had more severe memory and executive impairments.
Wade & Troy (2001)	Performance on 1-6 target behaviours selected with participant and carer. Performance recorded by carer	None	None	Improvement in all participants: P1: 5% - 100% and remained at ceiling after phone removed P2: 63% to 100% P3: 48% to 92% P 4: 43% to 100% P 5: 3% - 81%	Carers reported decreased burden. Authors comment on potential of mobile phones to increase independence, as they are also a means of contact in emergency.	Maintenance of effect after withdrawal reported in 1 patient (although period of follow-up not reported)	
McDonald et al (2011)	Performance on target activities selected with participant and carer. Performance rated by family member. Range 3-59 tasks, e.g. taking medication, completing domestic chores	None	Multilevel poisson regression models	Significant improvement in prospective memory performance in combined intervention phases vs baseline (improvement of 58% - 69%). Google calendar superior to normal diary (82% vs 55%).  Individual data showed 8/10 showed superior performance with Google calendar compared to standard diary, 2/10 showed no difference.	Authors comment that aid increases independence as patients are less reliant on prompting from carers.	None	Group data shows worse performance with standard diary compared to baseline, although this result is not commented upon.  11/12 participants were already using external memory aids on recruitment to study. Although they were asked to stop using these for the baseline period, positive results may reflect a pre-existing orientation to using external aids.  Those who benefited least were those with more severe memory and executive impairments.

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Lemoncello et al (2011)	Performance of 6 tasks: 2 preferred, 2 nonpreferred (chosen with client and carer) and 2 experimental (call to voicemail system and diary entry). Completion of non-experimental tasks logged by client or carer.	None	Mixed Model ANOVA	Significant advantage of Television Assisted Prompting (TAP, 72% completion) over usual practice (43% completion), and return to baseline when TAP removed.  No difference between preferred and non-preferred tasks	N/A	None	
Kirsch et al (1992)	Subunits of vocational task scored (cleaning bathroom and waiting room)	None	None	2 participants benefited from computerised instruction (S1: 55.28% to 78.26% correct; S2: 64.47% to 86.11%) with return to baseline on removal. 1 participant did not benefit (performance was already good with written instructions). 1 participant had equivocal results.	N/A	None	Performance was accurate enough for real world job performance but remained very slow.  Choice of task perhaps unmotivating - 4 participants dropped out.  Potential confound related to written instructions being presented all together whilst computerised instructions were presented one step at a time. Positive effects may have been achieved with flip cards without requiring computer.  Authors highlight potential for computers to provide an errorless learning experience.

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Brindley et al (2011)	1) Proportion "information units" from each event recalled correctly across 7 trials 1-4 weeks later 2) Affective response (heart rate) 3) Nature of recalled information,	None	Of heart rate data only	Significantly higher proportion of autobiographical events recalled in SenseCam condition than Automatic Thought Record or No Strategy conditions, and associated with more specific emotional elements. No differences between conditions in heart rate.	N/A	None	Designed to evaluate impact on therapy rather than everyday memory.  Only 1 event per condition, events may have varied in salience.  Automatic Thought Record condition was associated with less recall of autobiographical events than no strategy condition.
Shum et al (2011)	1) Cambridge Prospective Memory Test (CAMPRMPT), (performance of 3 time based and 3 event based prospective memory tasks) 2) No. diary entries related to everyday prospective memory tasks 3) Frequency of everyday memory lapses as measured by Part A of the Comprehensive Assessment of Prospective Memory (CAPM, carer ratings),	Sydney Psychosocial Reintegration Scale (SPRS)	Nonparametric analysis of difference scores (post-pre scores)	1 &2) Significant improvements in CAMPRMPT performance and diary entries with compensatory prospective memory training (CPMT) plus active control. On CAMPRMPT change was both statistically and clinically significant, with a move from "poor" to "average" functioning.  Contrary to hypothesis, the addition of self awareness training did not significantly improve functioning.  3) No change on carer-rated frequency of everyday memory lapses in any group.	No change on SPRS	None	Severe amnesia was an exclusion criteria.  Lack of change on CAPM measure may indicate that results of program were not having an impact in real life.

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Fleming et al (2005)	1) Psychometric testing (Memory for Intentions Screening Test, MIST) 2) Self report of prospective memory functioning (Part A of Comprehensive Assessment of Prospective Memory (CAPM)) 3) Assessment of diary use	Sydney Psychosocial Reintegration Scale (SPRS)	None	1) All participants improved on MIST 2) Mixed results for CAPM: some slight reductions in prospective memory failures, some slight increases. 3) Weekly diary entries increased from 27-82, 0-5 and 0-6.	SPRS showed better community integration for 2/3 participants	2 mth follow up of diary entries. P1 was making approx. 5 entries per day, P2 was making approx. 1 entry per day, P3 was making approx 1-2 entries per day.  Authors comment that generalisation is greatly aided by involvement of a carer.	Not clear whether improvement in MIST scores is clinically significant.  2 patients were studied soon after injury so improvement may reflect spontaneous recovery.  Self reported prospective memory problems did not reliably improve. May reflect increased awareness of memory problems as a result of training.  Follow up of diary use was self report so potentially less reliable.
Boman et al (2007)	1) Canadian Occupational Performance Measure (COPM) - self perception of change in occupational performance on 5 activities most important to client. 2) Experimenter rated ability to learn to use aids independently. 3) Participant ratings of usefulness of each aid and ease of learning	Sickness Impact Profile (SIP), Quality of Life Visual Analogue Scale (both self-rated)	Wilcoxon matched pairs signed ranks test	1) COPM showed significant improvement in self perceived performance and satisfaction with performance after intervention (improvement in 7/8 participants).  Large variation in time required for participants to learn how to use aids: 2-24 weeks (participants with greater memory impairment took 4 weeks longer to learn to use aids, and relied on checklists to guide their use).  All aids rated as useful and easy to learn by participants.	Significant improvement in body care and psychosocial functioning scales of SIP. Significant improvement in self perceived QOL.  Authors comment on potential for increased independence and ability to live in own homes for longer.	None	Participants had to be independent or in need of minimal assistance on FIM to be included – this may exclude group for whom aids would be most helpful.

Author	Outcome Measure (s)	Ax of Quality of Life / Well-being	Statistical analysis	Results	QOL / Well-being results	Follow-up	Comments
Boman et al (2010)	1) Daily rating of no. reminders needed to recall how to operate the aids 2) No. alarms activated by failure to close or turn off equipment.	None	Wilcoxon matched pairs tests, Spearman rank order correlation	1) Significant improvements at a group level in learning to use the aids from day 1-4 (3 participants achieved independent use, but 3 failed. 2) Significant improvement at group level in remembering to turn off TV but no improvement in remembering to close terrace door or windows, turn off refrigerator, stove or water. These failures did not correlate with performance on RBMT (even those in normal range on RBMT forgot these things to a significant extent).	N/A	None	High functioning sample – study excluded severe memory impairment and participants needed to be independent on FIM – this may exclude group for whom aids would be most helpful.  Alarms did not improve learning, i.e. no restorative effect, but presumably still had a compensatory effect (response when alarm sounded).  Data on diary and address book aids not reported.  Unclear which factors were associated with failure to learn to use aids. Lack of correlation between RBMT and failures indicates need for real life evaluation of memory failures before discharge.

### *3.2.1. Participant characteristics:*

In all, 374 participants were studied. Of those participants where aetiology was reported, 283 were TBI patients and 61 were stroke patients. Participants varied in time post-injury, from 2 months to 34 years, minimum time post-injury was not reported in three studies. There was a wide range in severity of memory impairment, with some participants having severe impairments, but others falling into the normal range on standardised memory testing. As with the studies on paper-based external aids, in most cases severity of impairment was categorised according to standardised measures such as the Rivermead Behavioural Memory Test (RBMT) or the Wechsler Memory Scale (WMS). In one case standardised measures were not reported but a clinical description of memory impairment was provided (Hart, Hawkey & Whyte, 2002). Information on severity of memory impairment was not reported in six studies. Only 13 of the 27 studies specified whether their participants also suffered from other cognitive impairments in addition to memory impairment. Of these, two studies reported no additional impairments, the remaining eleven all reported executive impairment (amongst other cognitive impairments).

### *3.1.2. Intervention characteristics:*

Six studies evaluated the use of a paging system, six studies evaluated personal digital assistants (PDAs), four studies evaluated voice organisers or voice recorders, three studies evaluated mobile phones, one study evaluated Google calendar, one study evaluated "Television Assisted Prompting", one study evaluated "Interactive Task Guidance" on a personal computer, one study evaluated "SenseCam", two studies evaluated compensatory aid training using a

device of the patients choice (diary or electronic organiser), and two studies evaluated “training apartments” equipped with a variety of electronic aids.

Most studies compared use of the electronic aid to baseline or to a “no intervention” condition. No studies compared external aids to other types of memory rehabilitation approach, but seven studies compared different external aids to each other. Six studies compared electronic aids to paper-based aids (Dowds et al., 2011; Giles & Shore, 1989; Van Hulle & Hux, 2003; McDonald et al., 2011; Kirsch, Levine, Lajiness-O’Neill & Schnyder, 1992; Brindley, Bateman & Gracey, 2011), and one study compared two electronic aids (Wright et al., 2001). One further study compared four different training programs using external aids (Shum, Fleming, Gill, Gullo & Strong, 2011).

Length of training varied between studies. Most studies gave no or minimal training on use of the electronic device. In some cases this was because the device required minimal operation (for example studies evaluating pagers or mobile phone message services, where the participant was only required to respond to an alarm and read the accompanying message). In other cases devices were more complex (e.g. PDAs, voice organisers or functions on mobile phones) but were programmed by, or under the direct instruction of, the experimenter, and no attempt was made to train the participant in independent use (Dowds et al., 2011; Kim, Burke, Dowds & George, 1999; Yasuda et al., 2002; Stapleton, Adams & Atterton, 2005). Of the studies that did provide training, Thone-Otto & Walther (2003) provided up to five one-hour sessions of training to use their PDA and mobile phone functions. However this appeared to be

adequate in only six of their twelve participants. The remaining six participants were reported hardly to have learnt even the most basic functions of the devices in this time, and ability to learn to use the devices correlated with scores on standardised memory testing. Gentry, Wallace, Kvarfordt & Lynch (2008) provided three to six 90-minute sessions of training in the use of their PDA and this appeared to be successful. However their participants all had prior knowledge of computers, and also all used some form of external aid prior to taking part in the study. Giles & Shore (1989) described an extensive training period in their single case study evaluating use of a PDA, involving four hours of individual training, six hours of practice with relatives, and a further month of use until the patient was proficient. However Wright et al. (2001) provided just one session of training in the use of their PDA before leaving their participants with a manual, and reported that all participants could use the functionality available when asked to do so. Hart et al. (2002) offered up to three training sessions in use of a voice organiser, which was sufficient in enabling their participants to use it for a circumscribed task. Two studies specifically evaluated training programmes for the use of external aids (Shum et al., 2011; Fleming, Shum, Strong, & Lightbody, 2005). In both cases the programmes lasted 8 weeks. In their training apartment, Boman, Tham, Granqvist, Bartfai & Hemmingsson (2007) employed errorless learning methods to train participants to use the external aids, and found that participants varied greatly in the length of time necessary to learn to use the aids, from 2 to 24 weeks. Like Thone-Otto & Walther (2003), they reported that those participants with greater memory impairment had greater difficulty learning to use the aids.

The majority of studies evaluating electronic aids were aimed at improving prospective memory functioning (19/27 studies). One study aimed to improve everyday memory performance and participation in everyday life tasks (Gentry et al., 2008), two studies evaluated new learning (Hart et al., 2002; Culley & Evans, 2010), one study evaluated performance on a vocational task (Kirsch et al., 1992), one study evaluated recall of anxiety related memories in therapy (Brindley et al., 2011), one study aimed to improve independent function and quality of life (Boman et al., 2007) and two studies evaluated ability to use the aids (Wright et al., 2001, Boman, Stenvall, Hemmingsson & Bartfai, 2010).

### *3.2.3. Measurement Characteristics:*

The most frequent outcome measures were performance on prospective memory tasks (17 studies) and ratings of everyday memory failures (6 studies). Of the studies that employed these types of ratings, four used self-ratings (Thone-Otto & Walther, 2003, Wright et al., 2001, Fleming et al., 2005, Boman et al., 2007), one used carer ratings (Shum et al., 2011) and one used joint ratings by the patient and carer (Gentry et al., 2008). Other outcome measures were measures relating to use of the external aid (four studies), ability to learn the external aid (three studies), standardised measures of prospective memory (two studies), recall of therapy goals (two studies), performance on a vocational task (one study), memory failures triggering household alarms (one study) and recall of anxiety related autobiographical memories (one study). Only two studies included ratings of satisfaction or usefulness of the aids (Thone-Otto & Walther, 2003; Boman et al., 2007).

Only six studies included measures assessing quality of life or well being. One study evaluated impact on carer strain (Wilson, Emslie, Quirk & Evans, 1999), one study evaluated participation in everyday life tasks (Gentry et al., 2008), one study evaluated impact on affect (van den Broek, Downes, Johnson, Dayus & Hilton, 2000), two studies evaluated psychosocial reintegration (Shum et al., 2011; Fleming et al., 2005), and one study evaluated quality of life and self-perceived dysfunction due to ill-health (Boman et al., 2007).

Sixteen of the twenty-seven studies conducted statistical analysis of their results.

#### *3.2.4. Results:*

*3.2.4.1 Pagers:* Six studies evaluated paging systems. Typically in these studies messages are selected by the client and/or carer in collaboration with the therapist, and are programmed into a central system either operated by a paging company (e.g. Neuropage: Fish, Manly, Emslie, Evans & Wilson, 2008; Hersh & Treadgold, 1994; Wilson et al., 1999; Wilson, Emslie, Quirk, Evans & Watson, 2005; Wilson, Evans, Emslie & Malinek, 1997) or operated in-house (Kirsch, Shenton & Rowan, 2004). At the appropriate date and time messages are transmitted to the individual pager, and an audio or vibration alarm alerts the patient to the message, which contains a reminder of the task to be carried out. Typical messages might relate to taking medication or meal preparation. Of the six studies that evaluated pagers, all reported positive outcomes associated with their use.

*Class 1 studies:*

Two class 1a studies re-analysed data from an earlier RCT (Wilson, Emslie, Quirk & Evans, 2001) restricted to participants with stroke (Fish et al., 2008) or TBI (Wilson et al., 2005). In the group with TBI, Fish et al. (2008) reported a significant improvement in completion of everyday tasks with the pager for 92% of their participants, but performance significantly decreased again after removal of the pager in 70%. In the group with TBI (Wilson et al., 2005) there was also a significant improvement in performance with the pager in 81% of participants, but only 46.67% showed a significant decrease in performance when the pager was removed. This represented an interesting difference in performance between the TBI and stroke groups. Fish et al. (2008) reported that the difference in response was related to degree of executive impairment: those patients with more severe executive impairment were more likely to return to baseline after removal of the pager, whilst those with less executive impairment were more likely to maintain their performance.

Although the results in both subgroups were overwhelmingly successful, there were still a small number of participants whose performance did not improve with the pager. Wilson et al. (2005) reported that this was more common in situations where a) the patient lacked insight into their memory deficit, b) the patient was so dependent on others that they were unable to carry out any activities independently, or c) where carers or relatives felt that they should do the reminding rather than an external device.

*Class 2 and 3 studies:*

Four other studies evaluating the effect of pager use on prospective memory reported similarly positive results (Hersh & Treadgold, 1994; Kirsch et al., 2004; Wilson et al., 1997, 1999), with significant improvements in completion of everyday tasks with a pager. These studies reported mixed results when pagers were removed, with some participants' performance returning to baseline and some maintaining their level of performance. Although individual differences were not analysed in these earlier studies, the Fish et al. (2008) analysis suggests that these differences may have reflected degree of executive impairment.

*Quality of Life / Well-being:*

None of the pager studies evaluated impact on participant quality of life or well-being, but there were anecdotal reports of increased independence with pager use (Wilson et al., 1997, 1999, 2005). In addition Wilson et al. (1999) reported significantly reduced carer strain in the wife of a single case who responded well to Neuropage.

*Follow up:*

Follow-up was uncommon in studies evaluating pager use, but the results suggested that in participants with less severe executive impairment, a seven week intervention with the pager was sufficient to establish a routine that could then be maintained without reminders. However maintenance of effect in these studies was only evaluated for a further seven weeks, so longer term follow-up

would be desirable. In those with more severe executive impairment, pagers may need to be used in the long-term to maintain performance.

***Summary: Pagers***

*Six studies, including two class 1 studies, reported improved prospective memory functioning with use of a pager. Patients with less severe executive impairment were able with a pager to establish a routine that could then be maintained without reminders. Assessment of quality of life and long-term follow-up was not reported in pager studies.*

3.2.4.2: *Personal Digital Assistants (PDAs)*: Six studies evaluated PDAs. PDAs are hand-held personal computers that are equipped with a variety of functions, such as diary, notebook, address book and reminder functions. Most PDAs have alarms which can be set to alert the user to a particular event. Of the six studies that evaluated PDAs, most showed generally positive results.

*Class 1 studies:*

One class 1a study evaluated the effect of two different types of PDA, a paper planner and a “no aid” baseline condition on prospective memory performance in 36 TBI patients, using a randomised crossover trial with an ABCDABCD design (Dowds et al., 2011). Performance was at 27% in the baseline condition, 26% with the paper planner, 38% with a Microsoft PDA, and 56% with a Palm PDA. Performance with both PDAs was significantly better than baseline, and performance with the Palm PDA was significantly better than with the Microsoft

PDA. However performance even with the Palm PDA was surprisingly low, at only 56%. In addition, messages were input for the participants, so performance did not reflect any ability to use the device independently, limiting the generalisability of the results. Interestingly the authors reported that performance was not predicted by gender, age or performance on cognitive measures (Wechsler Abbreviated Scale of Intelligence: Vocabulary or Matrix Reasoning subtests, Wide Range Achievement Test: Maths or Reading scores, or Wechsler Memory Scale: Logical Memory or Family Pictures subtests, see also Wright et al. 2001 for similar results).

*Class 2 and 3 studies:*

A class 2 study by Thone-Otto & Walther (2003) evaluated the use of a PDA or mobile phone agenda function on prospective memory functioning, assessing performance on 20 experimental tasks as well as patient-recorded everyday forgotten intentions. They did not compare results of the PDA to the mobile phone, but collapsed the results together. Although they reported that the number of experimental tasks and everyday intentions that were forgotten reduced with the electronic aids, this difference did not in fact reach significance. Moreover, examination of the data showed that performance appeared to be very close to ceiling, with only around 0.12% of experimental tasks being forgotten even at baseline. Unfortunately this aspect of the data makes interpretation of the true impact of the external aid very difficult.

In the class 3 studies evaluating PDA use, Gentry et al. (2008) reported significant improvement on ratings of everyday performance related to memory

functioning in a group of 23 TBI patients. Giles & Shore (1989) reported improvement in prospective remembering in their single case from 0/10 tasks at baseline to 9/10 tasks using a PDA (which was also slightly better than performance using a standard diary), Kim et al. (1999) reported anecdotal evidence of an improvement in attendance at therapy sessions and independent requesting of medication in their single case. Wright et al. (2001) reported that even after minimal training their 12 patients were making around 3 entries per day on their PDAs (assessed over 18 weeks with the aids), and rated the usefulness of their PDAs at 6.5 / 10. However 5 of their original participants dropped out (potentially because they found the PDA less helpful or easy to adopt), and only 3 of the 12 participants recorded forgetting things in the “no aid” phase that they would have used their PDA for had it been available to them. As this study did not include any objective assessment of the impact of the intervention on memory performance, this finding could be taken to indicate that only 25% of participants benefited from the PDA. However it may also reflect a problem with the use of self-report measures in participants who suffer from memory impairments, who may be less likely to remember their memory failures, or to complete memory logging tasks at all.

*Quality of Life / Well-being:*

Only one study reported data relating to quality of life or well-being. Gentry et al. (2008) reported a significant improvement in satisfaction with performance, and also on ratings of cognitive independence, mobility and occupation, but not physical independence, social integration or economic self-sufficiency.

*Follow-up:*

In the only study to report follow-up data, Giles & Shore (1989) found that their single case was still using the PDA at 3 month follow-up.

***Summary: PDAs***

*Six studies, including one class 1 study, reported generally positive results, but with some small effects, and with some methodological problems which limited the conclusions that could be drawn. One class 3 study reported improvements in quality of life, and another class 3 study reported continued use of a PDA at three-month follow-up.*

*3.2.4.3 Voice Organisers:* Four class 3 studies evaluated voice organisers.

*Class 3 studies:*

Hart et al. (2002) were one of the few studies to evaluate the impact of an external aid on new learning. They used an organiser with a chime which sounded three times a day to prompt their participants to play a recorded message reminding them of their therapy goals, and reported significantly greater recall of recorded than non-recorded therapy goals after 7 days. The other three studies evaluated the impact of voice organisers on prospective memory, and used devices which replayed stored voiced messages at set times. van den Broek et al. (2000) reported positive results in all 5 of their participants. However van Hulle & Hux (2003) found no improvement in the single case with whom they trialled a voice organiser. This patient also failed to

benefit from written reminders or a watch alarm, and they attributed his failure to respond to aids to a lack of motivation to be independent. Yasuda et al. (2002) reported mixed results, with the voice recorder proving an effective aid in five of their participants, but having no effect in the remaining three. The authors speculated that this might be due to executive problems in two of the patients, but the reason for failure in the third was unclear.

*Quality of Life / Well-being:*

*Only one study reported data relating to quality of life or well-being, however this was negative. Van den Broek et al. (2000) reported no effect of voice organiser use on positive or negative affect using the Positive and Negative Affect Schedule (PANAS).*

*Follow-up:*

None of the studies evaluating voice organisers reported follow-up data.

***Summary: Voice Organisers***

*Four class 3 studies evaluated voice organisers. One study reported positive effects on new learning. Three studies assessed prospective memory, twelve of sixteen participants benefited from the voice organiser. Assessment of quality of life in one study showed no impact. No study reported follow-up data.*

*3.2.4.4 Mobile Phones:* Three class 3 studies evaluated mobile phones as external aids.

*Class 3 studies:*

Culley & Evans (2010) replicated the study of Hart et al. (2002), reporting significantly greater recall of therapy goals that were sent by text message to participants three times a day, compared to unsent goals. Wade & Troy (2001) also reported positive results, with improved performance in five patients on a prospective memory task when prompted by voice messages sent to their mobile phone. However Stapleton et al. (2005) found that use of a mobile phone reminder function improved prospective memory performance in only two of their five participants. They reported that those who showed no improvement had more severe memory and executive impairments.

No studies evaluating mobile phones reported follow-up data, or data relating to quality of life / well-being.

***Summary: Mobile Phones***

*Three class 3 studies evaluated mobile phones. One study reported positive effects on new learning. Two studies assessed prospective memory: seven of ten participants benefited from the voice organiser.*

#### *3.2.4.5. Other electronic aids:*

##### *Class 1 studies:*

Two class 1a studies evaluated other electronic aids. McDonald et al. (2011) compared the use of Google Calendar (an online diary which allows linked reminder messages to be sent to a mobile phone by text) to a standard diary in a randomised crossover trial. They found no improvement on prospective memory performance with the standard diary compared to baseline (55% and 58% respectively), but a significant improvement with Google calendar, with performance reaching 82%. As with some other studies, their sample were already using external aids on recruitment to the study, so positive results may in part reflect a pre-existing orientation to using memory aids. Again echoing other studies, they reported that those participants with more severe memory and executive impairment showed least improvement.

Lemoncello Sohlberg, Fickas & Prideaux (2011) conducted a randomised crossover trial comparing usual practice to “Television Assisted Prompting” (TAP, messages which are delivered to the participant’s TV screen with an alerting tone). They reported a significant advantage of TAP, with performance on prospective memory tasks improving from 43% to 72%.

##### *Class 3 studies:*

Two other types of aid were evaluated by a single class 3 study each. Kirsch et al. (1992) evaluated the effect of “Interactive Task Guidance” (ITG, messages displayed on a computer screen) on performance of a vocational task (cleaning

a bathroom and waiting room). They reported that two participants performed better with ITG, one participant showed no improvement over written instructions, and one had equivocal results. Brindley et al. (2011) evaluated SenseCam, a wearable camera that takes photographs automatically in response to environmental changes. These photographs can then be compiled and viewed consecutively as an aid to autobiographical recollection. In this study, they evaluated the impact on recall of anxiety-related trigger events in the context of cognitive behavioural therapy for anxiety, and found that a significantly higher proportion of autobiographical events were recalled with SenseCam than with automatic thought records (traditionally used in CBT) or a no strategy condition.

No studies evaluating other electronic aids reported follow-up data, or data relating to quality of life / well-being.

***Summary: Other Electronic Aids***

*Amongst studies evaluating other electronic aids, two single class 1 studies reported positive results associated with Google Calendar and Television Assisted Prompting. Two class 3 studies showed mixed results for interactive task guidance, and promising preliminary results with SenseCam.*

***3.2.4.6. Training programmes with mixed aids:***

Two studies examined training programmes in the use of compensatory aids where the type of aid was not prescribed and participants selected the aid of

their choice (either a diary or organisational device).

*Class 1 studies:*

Shum et al. (2011) conducted a class 1 randomised controlled trial comparing four 8-week training conditions: 1) Self Awareness Training (SAT) + Compensatory Prospective Memory Training (CPMT), 2) SAT plus active control, 3) active control plus CPMT, and 4) active control only. They found significant improvements on a standardised test of prospective memory (CAMPRMPT) and a significant increase in diary entries, in the active control plus CPMT condition. Contrary to their hypothesis the addition of self awareness training did not appear to confer additional benefit. Although their results appeared positive with both statistically and clinically significant improvement on the CAMPRMPT, carer ratings of the frequency of everyday memory lapses did not improve in any group, raising some doubt about whether the program had an impact on real world memory functioning.

*Class 3 studies:*

A class 3 study by Fleming et al. (2005) also evaluated an 8-week training program in the use of a diary or electronic organiser. They reported improvement on a standardised test of prospective memory, but mixed results on self report of real-world prospective memory functioning.

*Quality of Life / Well-being:*

Both Shum et al. (2011) and Fleming et al. (2005) reported outcomes on the Sydney Psychosocial Reintegration Scale (SPRS). Shum et al. (2011) found no

change on this measure following intervention in any training condition, whilst Fleming et al. (2005) reported better community reintegration in two of their three participants.

*Follow-up:*

Fleming et al. (2005) reported that all three of their participants continued to make between one and five diary entries per day at two month follow-up. However this data was self-report, potentially affecting its reliability.

***Summary: Training Programmes with Mixed Aids***

*One class 1 study and one class 3 study reported that 8 week training programmes applicable to various external aids had a significant effect on standardised tests of prospective memory but not on real world functioning. Self awareness training did not confer additional benefit. Impact on quality of life was mixed with no improvement in the class 1 study.*

*3.2.4.7. Training apartments:* Two class 3 studies evaluated the use of “training apartments”, apartments equipped with a variety of electronic aids to assist with memory functioning as well as other aspects of independent occupational performance.

*Class 3 studies:*

Boman et al. (2007) reported significant improvement in self-perceived occupational performance, and satisfaction with this performance, in 8 patients after stays of 4-6 months in an apartment equipped with a variety of living aids

including memory aids (an electronic calendar with reminder lists and linked SMS messages, reminders of facility bookings, and a telephone equipped with photos of contacts). In a more recent study the same group reported a reduction in alarms triggered by forgetting to turn off the television in participants who stayed in a training apartment for a 5-day period (Boman et al., 2010). They reported no improvement in the number of alarms triggered by other memory failures. However this perhaps serves to remind us of the primary function of external memory aids as a compensatory rather than a restorative approach. Although participants did not stop being liable to these memory lapses (thus continuing to trigger the alarms), the alarms themselves presumably functioned to support memory performance in enabling the participants to correct their errors.

*Quality of Life / Well-being:*

Boman et al. (2007) reported a significant improvement in self-perceived quality of life and psychosocial functioning following stays in their training apartment.

*Follow-up:*

Neither study evaluating training apartments reported follow-up data.

***Summary: Training Apartments***

*Two class 3 studies report preliminary findings that training apartments may improve aspects of memory performance or self perceived occupational performance, as well as quality of life.*

#### **4. DISCUSSION**

The evidence for the efficacy of external memory aids is generally very positive. A large number of studies are now available, including 9 class 1 studies, all of which report improved memory functioning with use of an external memory aid. All 12 studies evaluating paper-based external aids (including 3 class 1 studies) reported positive outcomes, all 6 studies evaluating pagers (including 2 class 1 studies) reported positive results, 6 studies evaluating PDAs (including 1 class 1 study) reported generally positive results, 2 of 4 studies evaluating Voice Organisers reported positive results (1 negative and 1 mixed), 2 of 3 studies evaluating mobile phones reported positive results (1 mixed), and there were also positive reports of interventions using Google calendar (class 1 study), Television Assisted Prompting (class 1 study), SenseCam and training apartments.

Not only do external aids appear to be effective in the short-term, but, given sufficient training, diary use may be maintained in the long-term, and positive effects with some electronic aids may be maintained even after the aid is removed. External aids may also be associated with significant improvements in symptom distress, mood, carer strain, cognitive independence, community reintegration, psychosocial functioning and quality of life (Bergquist et al., 2009; Boman et al., 2007; Fleming et al., 2005; Gentry et al., 2008; Ownsworth & McFarland, 1999; Wilson et al., 1999). This positive evidence supports the increasing interest in external memory aids in rehabilitation settings, and their increasing availability through “memory aids clinics” (Wilson & Kapur, 2009).

However some gaps remain in the evidence base, and the evidence that is available also raises questions about which type of aid might be best, with which type of training, for which type of memory problem, and for which type of patient. These questions are discussed in turn below.

*Are external aids more effective than other types of memory intervention?*

Perhaps the largest gap in the literature relates to the question of whether, or in which situations, external aids are more effective than other memory rehabilitation approaches. Only one study compares the use of an external aid to alternative strategies (Zencius et al., 1990), and whilst this study reported superior performance with a memory notebook compared to three internal aids, there were methodological concerns which seriously limited the conclusions that can be drawn. Whilst we can be confident that external aids can have a positive effect, more studies are needed to provide evidence on the particular memory problems, participant groups or other circumstances for which external aids should be the intervention of choice over and above other rehabilitation methods.

*Which external aid is best?*

Six studies compared different external aids to each other. Studies comparing electronic aids to paper-based aids all found the electronic aids to be superior (Dowds et al., 2011; Giles & Shore, 1989; McDonald et al., 2011; Kirsch et al., 1992; Brindley et al., 2011). In fact in these studies, performance with paper based aids was often equal to or sometimes even slightly lower than baseline performance. However diary training in these studies tended to be significantly

less intensive than those in those evaluating paper-based aids alone (e.g. Dowds et al. 2011, McDonald, et al., 2011). If a diary is to be used, it appears that intensive training may be necessary, and a simplified version may be preferable to one that requires extensive cross-referencing between sections (McKerracher et al., 2005).

Overall there is strong evidence for the use of pagers, and strong evidence for paper-based aids such as diaries and memory notebooks when sufficient training is provided. The evidence for PDAs, voice organisers and mobile phones is currently less conclusive. Finally there is preliminary but promising evidence in support of some other systems such as Google calendar and SenseCam.

The choice of aid is likely to be guided by the unique advantages and disadvantages of each one, and the match between these features and the needs of the individual patient. Paper aids such as memory notebooks can be quite complex and require extensive training (e.g. Donaghy & Williamns, 1998; Sohlberg & Mateer, 1989). They require a lot of editing and updating, and are not suitable for patients with reading, writing or visual impairments. They may be bulky to carry around, and patients may forget to use them. Certain cognitive impairments may also make use of a memory notebook more challenging, for example decreased attention / concentration, slow processing speed, reduced language comprehension, problem solving impairments, mental inflexibility, learning problems, or executive difficulties (for example initiating use of the memory book or acting on the information in it, Burke et al., 1994). Social and emotional factors are also likely to play a role, for example social stigma or

unwillingness to use the aid, as well as the degree of family support (Burke et al., 1994, Donaghy & Williams, 1998).

However paper-based diaries and memory notebooks do come with two distinct advantages. One is that people tend to already be familiar with diaries, meaning that some prior knowledge can be built on. The second is that paper systems are multi-purpose, and can therefore be used not only to support prospective memory but a range of other functions too, for example new learning (in notes sections) and recall of day-to-day events (as a record of events is accumulated in the diary).

An immediate advantage of electronic systems is that they are active rather than passive, incorporating alerts to prompt the patient to consult the device, and reducing the risk of forgetting to use an aid. Alerts may also have a general orienting function, prompting orientation to time, taking stock and goal oriented behaviour (Culley & Evans, 2010, see also Manly, Hawkins, Evans, Woldt & Robinson, 2002). Some electronic aids may also be used with minimal or no training, especially where independent operation of the device is not required (e.g. pagers), although other types of electronic aid (e.g. PDAs) may still require extensive training if the participant is not already familiar with their operation. The evidence also suggests that in some circumstances a short term intervention with an electronic aid may be effective in establishing a routine that can then be continued without use of the device, reducing the costs of long-term use. Some of the advantages and disadvantages specific to particular types of electronic aid are discussed below.

Pager systems such as Neuropage (Hersh & Treadgold, 1994) were specifically designed to overcome some of the problems of other external aids. It is unobtrusive, there is no need for constant checking or updating, and it is quick and easy to learn (for everyday operation, no training is needed as the participant simply needs to look at the screen of the pager when the alarm sounds). Feedback is available, as the client can be asked to telephone to confirm completion of a task, and reminders can be sent until this feedback is received, or a carer alerted. Neuropage is also now available as an SMS service, enabling clients to use their existing mobile phones rather than a pager. However there are disadvantages. The messages must be lined up in advance by a third party, limiting how flexible the reminders can be. The system is also primarily designed to support prospective memory, and cannot be used as a record of new learning or past events. The length of the message that can be displayed is also restricted, and it is not suitable for those with visual impairments (although Hersh & Treadgold, 1994, reported plans to develop a version using a voice-based receiver, this is not currently available). Finally it carries a cost implication; it currently costs £60 a month to receive the Neuropage service.

PDAs have the advantage of carrying many more features than a pager, including reminders, to-do-lists, note-pages, diaries and calendars, and thus have the potential to support new learning and keep a record of past events, as well as helping with prospective memory. They also offer more opportunity for independent use than a pager. However their increased complexity requires increased training, meaning that they may be more suitable for higher

functioning patients, or those who were already using a PDA prior to their brain injury. PDAs are now becoming less widely used, as this range of functions is increasingly available in smartphones (see below),

Voice organisers are relatively simple and inexpensive, and may be programmed by the user rather than centrally (van den Broek et al., 2000). They also allow longer messages than can be displayed on pager screen (Yasuda et al. 2003), and may be used by those with reading, writing or visual impairments. However for many users auditory messages may be more stigmatising than visual or text messages, especially if used in public.

Mobile phones may be the least stigmatising as they are so widespread in the healthy population. They may be used to receive messages sent from an external service (like Neuropage), or used independently by programming reminders and alarms (Stapleton et al., 2007). They may be used to receive text or auditory messages so may also be used by those with visual deficits (Wade & Troy, 2001), and they may function as a safety device, as they can be used to contact a patient if they are missing, or for the patient to seek help if in trouble (Wade & Troy, 2001). Many smartphones now incorporate a variety of functions including diaries, to-do lists and notepages which make them more similar to PDAs in the functions that they are able to support. Moreover as use of smartphones in the general population increases, the brain-injured population will have more familiarity with these devices and rehabilitation professionals may be able to capitalise on this pre-existing procedural knowledge, thereby avoiding the need for extensive new training. However these potential

advantages have not so far been reflected in the literature, and further studies evaluating the new smartphones would be desirable.

The other electronic aids evaluated may also offer benefits to some patients. Google calendar is a free of charge service that may be a valuable means of organising alerts to be sent to a mobile phone, either by the individual or by a carer. SenseCam appears to have unique potential (over the other electronic aids discussed) to support autobiographical memory (see below). Other aids such as Television Assisted Prompting or Interactive Task Guidance may have more limited applicability as they are not designed to be portable systems. Finally, training apartments seem a valuable resource in preparing patients for discharge, but as they do not have a restorative effect, they may be worthwhile only if these aids are later available in the patients own home.

#### *What type of training is best?*

Length of training in the studies reviewed ranged from 1 day to 6 months, and also varied according to whether the aim was to teach independent use of the aid or not. For an aid to be useful participants should clearly be able to use it outside of the experimental or rehabilitation setting, but if independent use is challenging, electronic aids which are externally managed to minimise learning and training requirements may be more viable options.

When the aim is to establish independent use, the available evidence does provide some guidance on the type and length of training that might be optimal. Longer training may be necessary to establish independent use of complex aids

like memory notebooks and PDAs, and detailed training protocols have been proposed for memory notebooks (Burke et al., 1994, Donaghy & Williams, 1998, Sohlberg & Mateer, 1989). Length of training may also depend on degree of impairment, with longer training especially important for those with more severe memory problems (Thone-Otto & Walther, 2003, Boman et al., 2007).

Several studies identified methods that may be useful components of training programs. For example Donaghy & Williams (1998) used vanishing cues in their memory journal system training program, and Boman et al. (2007) employed errorless learning methods in their training apartments. Cicerone et al. (2011) also noted that errorless learning techniques are likely to be useful in teaching the use of compensatory strategies.

Shum et al. (2011) in their study made an effort to examine what the active ingredients of training programs might be, and contrary to their hypothesis found that a simple compensatory training program which did not include self awareness training achieved the best results. Self awareness training did not appear to confer any additional benefit, and indeed the group who received compensatory plus self awareness training performed worse than those who received compensatory training alone. The inclusion of other executive strategies in training may be beneficial however. For example Ownsworth & McFarland (1999) reported better maintenance of diary use and greater reduction of memory problems in a group who received “self instructional training” (a strategy encouraging identification of a goal, selection of a strategy, implementation of the strategy and checking of the outcome) in addition to

standard diary training. This seems especially important in the light of repeated reports that executive impairments may interfere with the successful adoption and use of external aids.

In terms of delivery of training, most studies used individual training. However one study highlighted the potential utility of group-based training approaches (Schmitter-Edgecombe et al. 1995). Two other studies used distance learning. Bergquist et al. (2009) reported successful results using online training via Instant Messenger, which could be a useful method where patients live far away from rehabilitation facilities or where travelling is difficult. However six participants in their study dropped out or were excluded, and in four cases this was due to missing appointments on the online system, a failure which is much more likely with more significant memory impairments. Dropouts were also less likely to already be using an external aid (17%, versus 64% who completed the program), indicating that this type of training may be more suited to a higher functioning group, to those already oriented to using external aids, or for delivery of top-up training after strategy use is established. The distance learning approach employed by Ownsworth & McFarland (1999), using a letter and follow up telephone calls, appeared inadequate to establish ongoing use of the aid.

*What type of memory problem are external aids best suited to?*

Most studies evaluating external aids examined their impact on prospective memory functioning. However there was also evidence that external aids may be useful in managing memory-related behavioural problems such as repetitive

questioning (Squires et al., 1996). Three studies also demonstrated that external aids may be effective in learning new information (Hart et al. 2002, Culley & Evans 2010, Zencius et al., 1990). Certainly external aids may be a useful tool for errorless learning (Kirsch et al., 1992), and this may be the mechanism by which routines can be established with pagers and some other electronic aids that are then maintained after removal of the aid (Fish et al., 2008; Stapleton et al., 2005; van den Broek et al., 2000; Wade & Troy, 2001; Wilson et al., 1997, 1999, 2005; Yasuda et al., 2002). However the studies addressing new learning did not compare external aids to an alternative training measure, and it is possible that the new learning resulted simply from rehearsal that could have been achieved without an external aid. As yet it is unknown whether an external aid is superior to other techniques such as vanishing cues in establishing new learning. Finally there is the question of whether external aids have a role to play in supporting retrospective memory, for example recall of what one has done that day. Although having a record of past events is often cited as an advantage of memory notebooks over electronic aids such as pagers, voice organisers and mobile phones, no study has actually evaluated the use of memory notebooks for this purpose, neither do any of them include anecdotal reports about whether participants use memory aids of this sort to refer back to past events. The only study to directly examine recall of autobiographical events used SenseCam (Brindley et al., 2011), and reported greater recall in the SenseCam condition. However SenseCam was used in this study to recall a single event, and it is more difficult to see how it might function as a general memory aid on a day-to-day basis, as the quantity of data accumulated would be very large, and procedures for reviewing and archiving would be complex.

Different memory aids may be best suited to different memory problems, and in some cases, a combination of aids might be better able than a single aid to address the full range of rehabilitation needs (Boman et al., 2010). Careful goal setting is likely to be critical in identifying the most suitable external aid. Interestingly in a survey conducted by Hart, Buchhofer & Vaccaro (2004), people with moderate to severe brain injury reported that the functions they most wanted from an aid were keeping track of money spent, remembering what people tell you, and keeping track of things you need to do. Although most of the aids reviewed here could address the last of these functions, it is not clear that existing aids match up at all well to the other requirements.

#### *Who do external aids work for?*

The studies reviewed here suggest that external aids are effective for most patients with stroke and TBI, but not all. The lowest rates of improvement were consistently associated with greater executive impairment, across studies and across aids (Fish et al., 2008; McDonald et al., 2011; Stapleton et al., 2005; Wilson et al., 2005; Yasuda et al., 2002; Zencius et al., 1991,). This lends further support to the suggestion that executive strategies might be a useful addition to compensatory aid training (Ownsworth & McFarland, 1999).

Other features associated with poor response to external aids were reduced awareness of deficit (Donaghy & Williams, 1998; Ownsworth & McFarland, 1999; Wilson, 2005), lack of motivation (van Hulle & Hux, 2003), initiation problems (Yasuda et al., 2002), increased dependence on others (Wilson, 2005), and lack of support for the external aid from relatives (Wilson, 2005). Those

patients with the most severe memory deficits may also face additional challenges in using external aids (McDonald et al., 2011; Stapleton et al., 2007)

Giles & Shore (1989) suggest the following criteria for useful intervention with an electronic memory aid: 1) average or near average intelligence, 2) retained or mildly impaired reasoning skills, 3) insight into deficits, 4) adequate ability to initiate behaviour, and 5) a functional disorder arising from significant memory impairment. These criteria appear quite restrictive, however there has been much progress in electronic aids since that time, and one would hope that external aids might also be of benefit to clients with more severe deficits. Indeed there is evidence that a dedicated training approach can be successful even in the most extreme cases of lack of awareness of memory deficits and resistance to using aids, (Burke et al. 2004; Sohlberg & Mateer, 1989), and Sohlberg & Mateer (1989) caution against using motivational issues as an excuse to abandon compensatory aid training when it is challenging.

The studies reviewed here included many more TBI than stroke participants. However some interesting aetiological differences emerged from the analyses of Wilson et al. (2005) and Fish et al. (2008). The stroke group were less likely than the TBI group to show maintenance of performance after the pager was removed, and this was related to greater executive impairment in the stroke group. This finding suggests that interventions with stroke patients may need to be longer term than with TBI patients. However executive impairments are also common in TBI, so it may be that clinicians should be guided by degree of executive deficit rather than aetiology per se in making decisions about length

or type of intervention. Other differences exist between stroke and TBI groups, for example in typical cognitive complaints, region of damage, and age of the patients, which may also impact upon the choice of intervention, but as yet the literature does not provide any clear evidence about the impact of these factors on response to external aids.

As yet there are no studies directly addressing the question of who would be most suited to which type of external aid. However it might be expected that those with milder impairments will be more likely to benefit from more complex aids intended for independent use (e.g. memory notebooks or PDAs), whilst those with more severe impairments might be more likely to benefit from externally controlled aids requiring minimal training (e.g. pagers or text message reminders). Portability, expense, training, degree of independent control, prior experience and personal preference will all be important factors in selecting an appropriate external aid. Memory aids clinics where clients can “try out” different memory aids before committing to buy them are likely to be a useful resource in this process (Wilson & Kapur, 2009).

*Methodological issues:*

Some methodological issues in the studies reviewed limited the conclusions that could be drawn, and these might be addressed in future studies. In terms of participant characteristics, many studies included participants in the early months after their brain injury, some as early as 2 months post-injury. This raises the risk that any improvement in performance may be due to spontaneous recovery rather than the effects of the intervention. Whilst

experimental design (e.g. ABA designs) can go some way to addressing this issue, it would be optimal for future studies to limit participants to those at least 12 months after injury, when most spontaneous recovery is likely to have been achieved. In a clinical setting of course, external aids may also be of benefit during the acute period.

A second problem was that many studies included participants with relatively mild memory impairment, often scoring in the normal range on standardised tests. In some cases this may reflect failure of standardised memory testing to capture everyday memory impairment. However it also raises the possibility that some participants did not have impairments that required memory rehabilitation, making them inappropriate for the evaluation of external memory aids. Even where memory impairments were present, many participants were already using aids prior to recruitment to the study, were able to learn to use new aids with very little training, or appeared to remember to use their aids during the intervention period with few problems, indicating a high level of functioning. Overall, few studies included severely impaired patients, and those that did often grouped them together with patients with less severe deficits, so our knowledge about whether and how external aids might be most helpful for the most severely impaired patients, who cannot recall one rehabilitation session to the next, is limited. Future studies might consider stratifying their samples on the basis of severity of memory or other cognitive impairment, to ascertain which aids and which training strategies are best suited to those with more severe deficits. Moreover, some studies failed to provide any information at all on the severity of memory impairment. Future

studies should at least offer a clinical description of the type of memory impairment they are addressing (and ideally also results on relevant standardised testing). The presence and extent of any additional cognitive impairment, especially executive dysfunction, which might impact on response to intervention, should also be described.

In terms of measurement characteristics, the type of outcome measures employed varied widely across studies. Measures evaluating use of the aid (such as number of diary entries) are interesting, but in order to evaluate efficacy it is necessary to include a measure of the impact of the aid on memory functioning. In this regard functional measures, for example performance on a prospective memory task, or assessment of everyday memory failures, are a more sensitive and more ecologically valid measure of outcome than standardised neuropsychological measures (Quemada et al., 2003, Wilson, 1987). This is particularly true because external aids are intended to perform a compensatory rather than a restorative function.

Consistent with this, standardised measures showed no improvement in the studies reviewed here, with the exception of standardised measures of prospective memory. Improvements on the CAMPROMPT were reported by Kime et al. (1996) and Shum et al. (2011). In both cases this improved score reflected an increase in note-taking during the test. This suggests that the CAMPROMPT may be a standardised measure that is sensitive enough to detect changes resulting from use of an external aid. However Shum et al. (2011) did not report any improvement on ratings of everyday memory failure in their

study, raising some doubt about the ecological validity of the CAMPROMPT, at least in this study. This finding underlines the importance of including a “real world” measure in evaluations of external memory aids. Fleming et al. (2005) reported improvement on the MIST in their study, which was particularly interesting as the use of aids is restricted in administration of this test. This suggests either that their training program had a restorative effect on some aspect of prospective memory, or that spontaneous recovery had occurred in their participants. However the greatest improvement in MIST scores was seen in a client 12 months post-injury, making spontaneous recovery less likely. Replication of this result would be desirable.

One of the most ecologically valid measures is assessment of everyday memory failures. However six studies used self-report versions of these measures (Ownsworth & McFarland, 1999; Bergquist et al., 2009 Thone-Otto & Walther, 2003, Wright et al., 2001, Fleming et al., 2005, Boman et al., 2007). The problem with self-report measures of memory performance is that awareness and memory impairments may interfere with the reliability of the data. Patients may under-report memory problems due to lack of insight, fail to remember their memory failures, or forget to fill in their memory logs at all. Alternatively an increase in awareness of memory problems as a result of the intervention may lead to increase in self reported memory failures, even if the intervention has been successful (this may have been a factor in the null results of Fleming et al., 2005). In the opposite direction, an improvement in self-ratings may be observed due to demand characteristics or a placebo effect (an effect to which studies with no control group are particularly vulnerable). For all of these

reasons corroborative measure are important, either in the form of supporting ratings from a carer, or (more reliably) objective measures of performance where completion can be monitored directly (e.g. experimental tasks such as calling a voicemail system). Where ratings are used, the findings of Schmitter-Edgecombe et al. (1995) indicate that daily records may be more sensitive to change than retrospective measures.

The aim of rehabilitation is not just to remediate impairment but also to improve quality of life and help restore social role functioning. However only eleven out of twenty-seven studies included measures of subjective wellbeing and quality of life. Some of these studies reported significant improvements in symptom distress, mood, carer strain, cognitive independence, community reintegration, psychosocial functioning and quality of life (Bergquist et al., 2009; Boman et al., 2007; Fleming et al., 2005; Gentry et al., 2008; Ownsworth & McFarland, 1999; Wilson et al., 1999), and anecdotal reports suggested that one of the major impacts of external aids could be the increased independence they bring. However not all studies reported positive results. Schmitter-Edgecombe et al. (1995) found no reduction in symptom distress in their study, McKerracher et al. (2005) reported no improvement in mood, Bergquist et al. (2009) found no improvement in community reintegration, van den Broek et al. (2000) found no change in affect, and Shum et al. (2011) found no change in psychosocial reintegration with use of an external aid. Further study of the factors determining whether improvements in independence, quality of life and subjective well-being are associated with external memory aids are required. The evidence suggests that the best rehabilitation outcomes result from

comprehensive-holistic programs of rehabilitation which include individualised cognitive and interpersonal therapies (Cicerone et al., 2011). This suggests that for best results, intervention with external aids should be offered as part of a wider program of rehabilitation.

In terms of design, some studies suffered from confounds due to order effects and counterbalancing which could be avoided in future studies. Others lacked important details of procedure or training which limited the conclusions that could be drawn. Finally, only half of the studies conducted statistical analyses of their results, and many of the studies which did not include statistical analysis were single case studies. Class 3 single case studies were included in this review (following Cicerone and colleagues) because single cases can provide useful preliminary information about the effectiveness of rehabilitation approaches, which may guide subsequent controlled studies. However well designed group studies involving statistical analysis are now necessary to address critical outstanding questions about external aids.

#### *Future research*

We now have good evidence that external aids can be effective in patients with mild-moderate memory impairment. However further research is needed to address whether and how external aids might be most helpful for the most severely impaired patients. Further comparisons between aids would also be desirable, to offer guidance on which aid is best suited to a particular client group, or to a particular type of memory problem. In particular, further research on whether external aids might be able to support retrospective memory for

autobiographical events would be valuable. Information on the critical length and type of training for different aids would also be welcome. And as technological advances are occurring at such a rapid pace, evaluation of newer technologies such as smartphones will be important. Indeed the pace of change means that the electronic aids of tomorrow are likely to be very different from those that have been evaluated to date, hopefully offering new benefits to those exploiting their potential as a memory aid.

In terms of response to aids, further study of the factors determining whether improvements in independence, quality of life and subjective well-being will occur is required. In addition more research on the factors predictive of sustained use after discharge, and generalisation to the patients own life would be welcome.

#### *Limitations of this review*

This review included articles evaluating the use of external aids for memory impairment in patients with acquired brain injury due to TBI and stroke. The exclusion of articles where the primary diagnosis was not TBI or stroke meant that some studies evaluating external aids in cases who had suffered other brain injuries, (e.g. due to infection) were not reviewed. Studies where external aids were used to address functions other than memory were also excluded. This is perhaps an artificial distinction as external aids may also be very helpful in managing the executive and attention impairments which frequently co-occur with memory impairment in acquired brain injury. The reader is directed to de Joode et al. (2010) for a recent review including studies addressing these issues.

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## **PART TWO: EMPIRICAL PAPER**

### **Investigation of a “déjà vécu” delusion in a single case with matched controls**

## **ABSTRACT**

**Aim:** To present a single case (EN) with a unique déjà vécu delusion, and experimentally explore the cognitive mechanisms underlying the condition.

**Methods:** The study employed a neuropsychological single case design. Full neuropsychological assessment was completed and seven experimental tests were administered to explore the cognitive mechanisms underlying EN's déjà vécu. Performance was compared to 10 matched controls.

**Results:** EN showed a marked false recognition effect for particular types of stimuli, and also had a severe source monitoring impairment in which he was completely unable to recall contextual information about the source of his memories. The results also indicated a dissociation between autobiographical and non-autobiographical episodic memory processing.

**Conclusions:** A "two-factor" theory of déjà vécu is proposed in which déjà vécu is suggested to arise from an abnormal sense of familiarity overlain with impairments in belief evaluation and monitoring processes. The dissociation between autobiographical and non autobiographical episodic memory processing is discussed in terms of differences in the degree to which personal and emotional associations are formed for these two different types of event. Finally, implications for the rehabilitation of déjà vécu and other paramnesic disorders are explored.

## INTRODUCTION

Memory disorders are a common consequence of brain injury, and pose significant problems for the sufferer in day to day life. They also pose a significant rehabilitation challenge, as rehabilitation professionals try to uncover the best ways of ameliorating or compensating for changes in memory functioning. The most common form of memory disorder is amnesia, the loss of pre-existing memory, or the loss of the ability to form new memories. These are disorders involving the absence of memory. However there are also memory disorders in which the critical feature is not the *absence* of memories, but the *presence* of incorrect memories, conditions sometimes known as paramnesias.

In normal life, the closest we come to this type of experience is probably déjà vu. Déjà vu describes the strange sensation that one has already encountered the current situation at some point in the past. As well as being a feature of some neurological conditions, most notably temporal lobe epilepsy (Wild, 2005), it is also a relatively common phenomenon in neurologically normal populations, with estimates that approximately 60% of people have experienced it (Brown, 2003). The defining feature of déjà vu is that it is a disorder of familiarity – one feels that the current situation is familiar, despite the certain knowledge that this cannot be so. However a pathological form of déjà vu, known as “déjà vécu” has recently been described (Moulin, Conway, Thompson, James & Jones, 2005; Moulin, Turunen, Salter, O'Connor, Conway, & Jones, 2006; Tabet & Sivaloganathan, 2001; Thompson, Moulin, Conway, & Jones, 2004). In déjà vécu, the sense of déjà vu is persistent and convincing rather than being fleeting, and

patients genuinely believe that they have lived through the current moment at some previous time. These beliefs can take on a delusional intensity, and result in considerable disruption in day to day life.

Moulin et al. (2005) described a detailed experimental investigation of two patients with déjà vécu. Patients AKP and MA both had diffuse temporal lobe pathology, and both presented with the belief that they had already experienced events before. They had withdrawn from previously enjoyed activities, for example reading and watching TV, because they felt they had seen it all before. This sense of déjà vécu also permeated their daily activities, for example AKP complained that every time he went for a walk “it was the same bird in the same tree singing the same song” (Moulin et al., 2005, p 1364), and MA felt that she could predict the future, as she had lived through it all before.

In an elegant series of experiments Moulin et al. (2005) demonstrated that both patients shared a characteristic pattern of memory impairment. First, they showed high levels of false positives on recognition tasks. Second, they had an overextended recollective experience for items which they falsely recognised. Recognition memory can be subdivided into two component processes: recollection and familiarity. Recollective experience is characteristic of genuine memories, as it involves recall of details (images, thoughts and feelings) associated with the event. In this way it differs from familiarity, which lacks the detail of recollection but is characterised by a more general feeling of having encountered the information before (Gardiner & Richardson-Klavehn, 2000, Yonelinas, 2002). AKP and MA, rather than simply indicating that the items felt

familiar, actually reported that they remembered the prior (non-existent) presentation of the items. Third, they showed a tendency to produce “recollective confabulations” to justify their déjà vécu, in which they provided false details and false accounts of having experienced items and events before. On the basis of this evidence Moulin et al. (2005) concluded that in contrast to déjà vu (a disorder of familiarity), déjà vécu is a disorder of recollection, resulting from damage to fronto-temporal circuits which monitor and control experiences of remembering.

This study presents a new case of déjà vécu, with a unique presentation in which déjà vécu is entirely restricted to non-personal events. The study aims to further examine the cognitive mechanisms responsible for the disorder, with a view to informing both our understanding of normal memory function, and our understanding of how to rehabilitate memory disorders of this type.

## **CASE DESCRIPTION**

We saw EN when he was 38 years old, after he was referred for assessment of an “apparent delusional condition”. Twelve years prior to this, EN had suffered a severe closed head injury when he fell from a cliff. Hospital reports from the time indicate a head injury involving combined hypoxic and diffuse axonal damage, and a depressed fracture of the left frontal bones. Initial Glasgow Coma Scale score was 6, and he remained in post-traumatic amnesia for four months. In the initial stages of recovery he was mute but could communicate by writing

(although this was bizarre with jargon). He was discharged home five months after his accident to live with his father. His neuropsychological report on discharge indicates a severe memory impairment, word finding difficulties and executive functioning impairments with lack of insight into his difficulties. At that time he had a Verbal IQ of 86, a Performance IQ of 66 (Wechsler Adult Intelligence Scale - Revised), and an Immediate Memory Index of 75 (Wechsler Memory Scale - Revised).

When assessed 12 years later EN was cheerful, alert, fully oriented and appeared to have made a remarkable recovery. He provided a full history and reported that he could remember events up to and including part of the fall. EN was unable to work due to residual back and neck pain and remained living with his father, supported by disability benefit. He was taking medication for headaches and reflux, but no other medications. He reported two other head injuries, both prior to his fall; on both occasions he was struck on the head by a cricket ball and was concussed but made a full recovery. He had no other neurological or psychiatric history.

When questioned about any lasting effects of his accident, EN reported that he had some problems with his memory, and felt he was more impatient than he used to be. He did not report any other problems. However his father reported significant problems consistent with *déjà vécu*. He said that EN had delusions about events re-occurring, especially with large sporting events that he was watching on television. When EN saw these events on television he insisted that he had already seen them before. He always reported that he had seen them in

1994 when he was in the Brain Injury Unit of the hospital where he had been treated following his accident. His father reported that EN was absolutely convinced that he had seen these events before, and could not be reasoned with about the inconsistencies these beliefs entailed. Indeed he would occasionally become aggressive if his beliefs were challenged.

EN was interviewed in detail about his *déjà vécu* experiences. When asked whether he ever felt that the same things happened to him more than once, EN responded that he did feel this way about things that he read in the papers and watched on TV, specifically for sport, soap operas, and news. For example when EN was interviewed, the Australian cricket team had just played the first international Twenty20 game against South Africa in Australia, and were soon to travel to South Africa for the away game. EN told us that he had already seen these matches in 1994 when he was in hospital after his head injury.

EN described experiencing this feeling for numerous sporting and news events, including several cricket matches, the July 2005 bombings in London, and the 2004 tsunami. He did not believe that the events themselves were happening twice, but believed that they had happened just once in 1994, and were later repeated on the television as if they were current events. He reasoned that this was because Sydney (where he had been hospitalised in 1994) had television programming that was significantly ahead of his small rural home town, which he believed was screening events several years after they had occurred.

*EN: I saw the tsunami and I said "That happened when I was in hospital in Sydney!" And I said – "We're finally catching up!". I thought "get over the déjà vu, I'll be able to start living a normal life now!"*

*Experimenter: So when did the tsunami actually happen? What year?*

*EN: Well I reckon I saw it when I was in hospital in 1994.*

*Experimenter: And they were showing reports of the 1994 tsunami more recently?*

*EN: Yeah. They were finally showing in the country what I saw in hospital in 1994.*

EN was asked whether what he experienced was similar to the regular feeling of déjà vu that everyone has once in a while:

*Experimenter: Have you heard the term déjà vu? Is there any difference between that and the kind of thing you experience?*

*EN: Well everyone says "you only think you've seen it before". But I'll swear black and blue that I have seen it before.*

*Experimenter: So with these kinds of events ... with the sports and everything else, you're sure that you've seen it before?*

*EN: Yeah I'm 100% sure that I saw it when I was in hospital.*

EN commented that when he told people about these experiences they regularly challenged him to tell them what was going to happen, or, in the case of sporting events, what the outcome of the match was. However he said that he could not always remember the exact details of events due to his memory problem.

*EN: People say "Well if you've seen it can you remember what's going to happen?" And I say "Well sometimes your memory gets it right and sometimes it gets it wrong".*

*EN's father: Actually with that Twenty20 match the other night you said "I know who wins this but I won't tell you, I won't spoil it for you".*

*EN: Yeah.*

EN does admit to some occasional confusion regarding his beliefs. For example on one occasion his brother went to see a live cricket match, but EN remembered seeing this same match on television in 1994. EN struggles to explain this incident. However he is very resistant to any challenge to his beliefs.

*Experimenter: When you see things now and you remember already having seen them in 1994, does anyone try to tell you that you're mistaken?*

*EN: Well people say "It's live!" And I say "Yeah, well, whenever they take the picture it's always live – but it's just the programming of the stations, that's why you've got it now".*

*Experimenter: So when people say that it is live and that it's happening now you don't think that they're right?*

*EN: No, I reckon I saw it when I was in hospital and that's when it was on then.*

*Experimenter: And why do you think that they always repeating programs just from that period in 1994? Why don't they repeat things from 1996 or 1998?*

*EN: Oh well I just put that down to the programming of the stations.*

*Experimenter: Right. But they don't repeat programs other than from those 6 weeks (that you were in hospital). Is that right?*

*EN: Well, I don't know because I wouldn't have seen any more after that. I was gone then!*

*Experimenter: What would you think if I told you that sometimes after head injuries people get the feeling that things that they are seeing now have happened before, but actually they didn't. That actually it's a consequence of having had a head injury.*

*EN: Well your mind can make you believe what it wants.*

*Experimenter: Yes that's the difficulty. Do you think that could have happened to you?*

*EN: Um....(long pause). Well that's what everyone says, but I still remember lying in bed and watching it on TV. I can remember the TV, sitting in bed and watching it on TV.*

EN's déjà vécu is so pervasive that he does not appear to experience any news or sporting events as current, or as having occurred later than 1994.

*Experimenter: When you're watching the news, do some items seem completely new to you, that you haven't seen before?*

*EN: Um, no, I think I've heard all of it.*

*Experimenter: All of it?*

*EN: Yes, the news and the sport.*

*Experimenter: Can you tell me about a few big sporting or news events which have happened between '94 and now? What have been the major things in the news since your accident?*

*EN: Um... what they say now I reckon I've seen it in '94, so to me its not news it's just old news.*

*Experimenter: Have there been any new things that have happened between '94 and now?*

*EN: Not that I can think of off-hand.*

*Experimenter: Nothing in the news? No world events?*

*EN: I can't think of any. Like I reckon I saw those Bali bombings, the tsunami, Australia losing the Ashes, the Olympics, the tri-nations. I came back and I said "England beats them in the football!", I said "Australia loses the tri-nations" and they said "No!", and I said "You watch". So I don't think I would say anything, no.*

*Experimenter: There have been no big events between '94 and now?*

*EN: Not that I can think of. Not that, as I say, I hadn't already seen.*

For EN, world events stood still in 1994.

#### *Aims of the study:*

The aim of this study was to explore the mechanisms underlying EN's déjà vécu delusion using a neuropsychological single case design. In order to do this a full standardised neuropsychological assessment was conducted, and seven new experimental tests were designed and administered. These were conducted with EN and 10 matched controls. The experimental investigations had two main objectives. First, to explore the extent and nature of EN's delusional, confabulatory and déjà vécu experiences (Objective 1), and second, to explore the cognitive mechanisms responsible for his déjà vécu (Objective 2). The neuropsychological assessment and

the two experimental objectives are presented separately below. For clarity, methods and results are presented for each test in turn.

## **METHODS AND RESULTS**

### **Standardised Neuropsychological Assessment**

EN's performance on standardised tests assessing intelligence, executive functioning and memory can be seen in Table 1. On the WAIS-III, performance was in the Average range apart from Processing Speed, which was in the Low Average range. Memory functioning as measured by the WMS-III was lower than would be expected on the basis of his general level of intelligence, with five of the eight index scores significantly lower than his full scale IQ. Similarly his performance on the California Verbal Learning Test and Doors and People test indicated significant problems with memory, although Story Recall was preserved. In terms of executive functioning, EN had impairments in response suppression (as measured by the Hayling test), and set-shifting (as measured by the WCST). However his resistance to interference (Stroop), planning (Tower of London), cognitive estimation, verbal fluency and sustained attention were within normal limits.

**Table 1:**  
Standardised Neuropsychological Assessment (\* indicates performance in the impaired range).

Test	Patient EN	Test	Patient EN
<b>Intelligence:</b>		<b>Memory:</b>	
<i>WAIS-III (Wechsler, 1997)</i>		<i>WMS-III Index Scores (Wechsler, 1997)</i>	
Verbal IQ	101	Auditory Memory	86
Performance IQ	92	Visual Immediate	65
Full Scale IQ	98	Immediate Memory	71
Verbal Comprehension	96	Auditory Delayed	80
Perceptual Organisation	95	Visual Delayed	68
Working Memory	108	Auditory Recognition Delayed	90
Processing Speed	88	General Memory	74
		Working Memory	96
<b>Executive Function:</b>		<i>Story Recall (Coughlan &amp; Hollows, 1985)</i>	
<i>Hayling Test (Burgess &amp; Shallice, 1997)</i>		Immediate Story Recall	33/56 (50 %ile)
Part A Sensible Completion	6 (Average)	Intrusions in Immediate Story Recall	3
Part B Unconnected Completion	5 (Mod. Average)	Delayed Story Recall	30/56 (25-50 %ile)
Error Score	3 (Poor) *	Intrusions in Delayed Story Recall	3
<i>Stroop (Golden &amp; Freshwater, 2002)</i>		<i>California Verbal Learning Test (Delis et al., 2000)</i>	
Word Score	T = 44	Trials 1-5 Free Recall Total	T = 30 *
Colour Score	T = 54	List B Free Recall Correct	Z = -1.5
Colour-Word Score	T = 60	Short Delay Free Recall Correct	Z = -2.0 *
Interference Score	T = 57	Short Delay Cued Recall Correct	Z = -2.0 *
<i>Tower Of London (Shallice, 1982)</i>		Long Delay Free Recall Correct	Z = -2.5 *
Trials Correct	12/12	Long Delay Cued Recall Correct	Z = -2.5 *
Trials Solved in Minimum Moves	8/12	Total Intrusions	Z = 3.5 *
<i>Wisconsin Card Sorting Test (Milner, 1963)</i>		Long Delay Yes/No Recognition Hits	Z = -3.0 *
Categories	1 (2-5%ile) *	Long Delay Yes/No Recognition False Positives	Z = 3.5 *
Total Errors	64/128 (1 %ile) *	Long Delay Forced Choice Recognition	16/16
Perseverative Errors	26 (4 %ile) *	<i>Doors &amp; People (Baddeley et al., 1994)</i>	
Failures to Maintain Set	2 (11-16 %ile)	Visual Memory	<1 %ile *
<i>Cognitive Estimates (Shallice &amp; Evans, 1978)</i>		Verbal Memory	<1 %ile *
<i>Controlled Oral Word Association (Heaton et al., 2004)</i>	T = 33	Recall Memory	<1 %ile *
<i>Elevator Test of Sustained Attention (Robertson et al., 1994)</i>	7/7 (normal)	Recognition Memory	<1 %ile *

## **Objective 1: Exploration of EN's Delusional, Confabulatory and Déjà Vécu**

### **Experiences:**

#### *i) Delusion Interview*

It was unclear whether, in addition to déjà vécu, EN might also be experiencing a wide range of unusual beliefs. In order to investigate this, a semi-structured interview was designed consisting of a series of questions assessing for the presence of a range of false beliefs, delusions, hallucination and reduplications (see appendix i). EN reported a false belief that his brother was repeatedly stealing his clothing and possessions, which had led to the breakdown of their relationship. However he reported no other false beliefs, delusions, hallucinations or reduplications apart from his déjà vécu experiences.

#### *ii) Confabulation Battery*

In order to explore whether EN's déjà vécu extended to a general tendency to confabulate, he was given a modified confabulation battery based on that developed by Dalla Barba, Cipolotti & Denes (1990; see appendix ii).

#### **Method:**

The 45-item battery consisted of 10 questions probing personal semantic memory (5 remote and 5 current), 10 questions probing general semantic memory (5 remote and 5 current), 15 questions probing personal episodic memory (5 remote, 5 current and 5 future), and 10 questions to which most participants would be expected to answer "I Don't Know" (5 semantic and 5

personal episodic). Questions were put to EN in a random order, and responses were scored as “correct”, “confabulation” or a “don’t know” response.

#### Results:

EN produced only 3 confabulations out of a possible 45. All of these concerned general semantic information. When asked what happened to President Kennedy, he mentioned as part of his (otherwise accurate) response that the fellow who shot him had recently been released from prison. When asked what event had taken place in New Orleans the previous year (Hurricane Katrina) he responded that terrorists had hijacked an aeroplane, although he readily accepted that this was an error when corrected. The third confabulation related directly to his *déjà vécu* (when asked what happened in Bali the previous year, he accurately described the Bali bombings, but insisted that this had originally happened in 1994). All other questions were answered appropriately, and his father did not report any problems with spontaneous confabulation. Hence there is no evidence of a generalised confabulatory disorder. Rather, EN’s presentation appears to be one of circumscribed *déjà vécu*.

#### *iii) Dating Battery*

There were three striking aspects to EN’s *déjà vécu*. First, it seemed to be entirely restricted to non-personal events. This is in contrast to previous reports of *déjà vécu*, which have described *déjà vécu* affecting personal and non-personal events. For example, similar to EN, Moulin et al.’s (2005) patient AKP refused to watch TV or read the newspapers because he said he had seen it before. However AKP also experienced *déjà vécu* for personally experienced

events, for example when he went for a walk he would complain that drivers must have very regular habits as the same cars always passed by at the same time each day. Similarly patient MA experienced déjà vécu for television programs and news events, believing that she knew the number of people killed in the terrorist bombing in Bali. However she also experienced déjà vécu for personally experienced situations, for example during a visit to an electrical store she became convinced that she had already been to the same store and sat on the same chairs with the same people in the room. In sharp contrast, whilst EN regularly experiences déjà vécu for sporting and news events encountered on television and radio, neither he nor his father could recall any incidences where this had happened for personally experienced, autobiographical events. Secondly, EN's déjà vécu was extraordinarily time-specific. In contrast to other reported cases of déjà vécu, EN reported that all events for which he experienced déjà vécu had originally been encountered at the same time: in 1994, whilst he was in hospital. Thirdly, EN was completely convinced by his déjà vécu experience. No attempts to reason with him could persuade him that he might be mistaken. In order to explore these impressions experimentally, a battery was designed to assess EN's ability to accurately date events from different time periods.

#### Method:

EN was presented with brief descriptions of 40 events. 20 were well-known news and sporting events, and 20 were events which had happened to him personally. Details of these personal events were obtained from his father. Within each category, 10 events had occurred prior to his accident in 1994, and

10 had occurred after his accident (see appendix iii). An account of each event was read individually to EN in a random order, and he was asked to estimate which year the event had occurred in. After he gave a date for each event, EN was also asked to give a rating of how confident he was that his response was correct. He was asked to give a figure between 0% and 100%, where 0% meant "I am not at all sure that this date is correct" and 100% meant "I am totally sure that this date is correct".

#### Results:

EN's performance on the dating battery is shown in figure 1. He was able to provide relatively accurate date estimates for both personally experienced events and for news and sporting events which occurred prior to 1994. However there was a dramatic dissociation in his ability to date events which occurred after his accident. Whilst his ability to estimate the date of personal events was unaffected, he was no longer able to provide accurate date estimates for news and sporting events. Instead he estimated that nine out of the ten post-1994 events occurred in 1994, whilst he was in hospital following his accident. The only event which he did not attribute to 1994 was the 9/11 terrorist attack on the US. For this item he originally provided a date estimate of 1994. However he then commented that the event had happened in September, and he hadn't been in hospital in September 1994. He reasoned therefore that the event must have happened in September 1993, but that he had not seen it on television



until he was in hospital in 1994<sup>1</sup>.

A 2x2 ANOVA conducted on EN's confidence ratings for his date estimates showed no difference in confidence judgements between pre-accident and post-accident events (Figure 1: main effect  $F_{(1, 36)} = 1.20$ ,  $p = 0.28$ ), and no difference in confidence judgements between personal and news / sporting events (main effect  $F_{(1, 36)} = 2.62$ ,  $p = 0.11$ ). However there was a significant interaction ( $F_{(1, 36)} = 10.69$ ,  $p = 0.002$ ), with EN's confidence at ceiling for post-accident news and sporting events. He reported that he was 100% confident that all ten post-1994 news and sporting events had occurred in (or before) 1994.

#### Objective 1: Summary:

The results of the experiments described so far indicate a remarkably specific déjà vécu disorder. There is no evidence of other delusional beliefs, or of a general confabulatory disorder. Nor is there any evidence that EN experiences déjà vécu for personally experienced, autobiographical events. Instead EN experiences déjà vécu which is domain-specific (for news and sporting events, nearly always encountered in the media), time-specific (all events are reported as having first been encountered in 1994) and associated with pathologically high confidence.

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<sup>1</sup> EN did date one pre-accident news event as having occurred post-1994. When asked "When did the Berlin wall come down?" he responded "Um...say the 90s... I'm only guessing there." When pushed for a specific year he responded "Make it half way, say '95". This response did not therefore seem to be based on a recollection of a news event that took place after his accident, but was a guess.

## **Objective 2: Experimental Tests Exploring the Cognitive Mechanisms**

### **Underlying EN's Déjà Vécu:**

In order to explore the cognitive mechanisms underlying EN's déjà vécu a series of experimental tests derived from those used by Moulin et al. (2005) were administered. These assessed: i) EN's metacognitive ability; ii) his tendency towards false positives; iii) whether there was evidence for overextended recollective experience; and iv) memory for temporal and contextual source. The aim was to see if EN's déjà vécu was associated with the same pattern of impairments as Moulin et al.'s (2005) patients, AKP and MA. On each test EN's performance was compared to that of 10 male volunteers matched for age (mean 37.1 yrs, SD = 4.56) and years of education (mean 14.4 yrs, SD = 2.24). EN's performance was compared to controls using Crawford & Garthwaite's (2002) modified t-test, which allows comparison of an individual patient's score with a small control sample. One-tailed tests were used to test the hypothesis that EN was impaired on these tasks compared to controls.

#### *i) Feeling of Knowing Task*

One hypothesis is that EN's déjà vécu might be the result of generally disordered metacognitive abilities, which would disrupt his ability to accurately evaluate the content and process of his memory. In other words EN may feel that he knows most things, even if he doesn't get them right. In order to explore this possibility a "feeling of knowing" (FOK) task based on that described by Moulin et al. (2005) was administered (see appendix iv).

Methods:

EN and controls were required to recall answers to 50 general knowledge questions (e.g. *In which country did Chess originate?*) with instructions not to guess. For those questions they were unable to answer, they were asked to predict how likely it was that they would recognise the answer if presented with four alternatives. These FOK predictions were made on a three-point scale: “I am certain I will be able to recognise this answer later / I am quite sure I will be able to recognise this answer / I will have to guess”. Immediately after the recall phase participants were given the recognition phase. In this phase they were provided with the same general knowledge questions but this time were required to select the correct answer from four alternatives (e.g. *In which country did Chess originate? a) England; b) Germany; c) India; d) Italy*). Participants with good metacognitive abilities are expected to make higher FOK judgements for items which are ultimately recognised correctly, and lower FOK judgements for items for which they ultimately select the wrong answer.

Results:

**Table 2:**

*Feeling of Knowing Task (\* = significantly different from control  $p < 0.05$ ).*

	<b>Control Mean</b>	<b>Control Std. Dev.</b>	<b>EN</b>
<b><i>Recall Phase</i></b>			
Correct Recall (Max 50)	22.00	7.90	7
Incorrect Recall (Max 50)	1.9	1.6	8 *
<b><i>Recognition Phase (includes only those items not answered in recall phase)</i></b>			
Proportion “Certain” responses	0.17	0.19	0
... later recognised correctly	0.85	0.13	N/A
Proportion “Quite sure” responses	0.30	0.14	0.69 *
... later recognised correctly	0.78	0.12	0.67
Proportion “Guess” responses	0.53	0.25	0.31
... later recognised correctly	0.54	0.16	0.36

EN's performance on the feeling of knowing task can be seen in table 2 alongside the performance of the control group. EN's correct recall of answers to the general knowledge questions was low but did not differ significantly from control performance. However his incorrect recall was significantly higher than controls ( $t = 3.66, p = 0.003$ ). This offers some indication of reduced metacognitive accuracy, as participants were specifically instructed not to guess unless they were sure of the answer.

However EN's performance on the recognition phase did not suggest that he had generally reduced metacognitive accuracy. The only measure on which he differed significantly from controls was the proportion of "quite sure" responses he made. He was significantly more likely to use this response category than controls ( $t = 2.66, p = 0.01$ ). EN did not use any "certain" FOK responses, which may partly explain this result. However there was no significant difference between EN and controls in terms of the proportions of "quite sure" and "guess" responses which were later answered correctly. Both controls and EN showed an appropriate slope whereby those questions assigned "quite sure" FOK judgements were more likely to be answered correctly than those assigned "guess" FOK judgements, and EN's response accuracy did not differ significantly from controls. EN did seem able to make accurate feeling of knowing judgements which reflected his later memory performance. Like Moulin et al.'s (2005) patients, *déjà vécu* in EN does not seem to result from a dysfunctional feeling of knowing in which he feels he knows everything.

## *ii) Famous Faces Test*

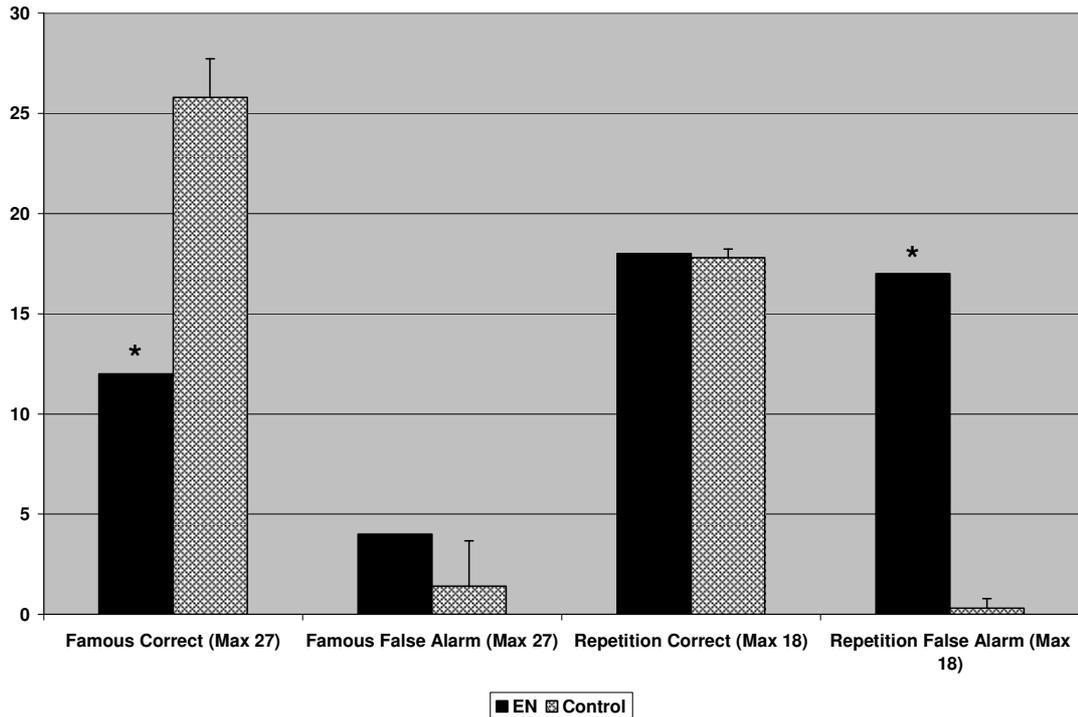
Moulin et al. (2005) reported that both of their cases showed high levels of false positives on recognition tasks. In order to explore whether EN shared this tendency towards false positive responding EN was given a face recognition task based on that used by Moulin et al. (2005).

### Methods:

Participants were shown a series of photographs of faces, and were required to make two judgements for each photograph. First they were asked to indicate if the person in the photograph was famous or not (a semantic memory judgement). Second they were asked to indicate if they had seen the photograph already in the test session (an episodic memory judgement). 54 photographs were presented individually: 18 stimuli were presented once and 18 were presented twice. In each of these sets of 18, half of the faces were famous and half were non-famous.

### Results:

Compared to controls, EN showed a significant reduction in the number of faces he was able to identify as famous (Figure 2:  $t = -6.818$ ,  $p < 0.001$ ). His semantic memory false alarm rate (the number of non-famous faces he misidentified as famous) was normal. However in terms of identifying pictures which were repeated (episodic memory), EN showed a normal hit rate but an enormous



**Figure 2: Performance on the Famous Faces task. \* indicates significant difference between EN and control performance  $p < 0.05$ .**

false alarm rate ( $t = 33.173$ ,  $p < 0.001$ ). EN identified 35 out of the 36 images as having been seen already in the experiment. The only face he said he had not seen already was the first face presented in the run.

Déjà vécu patients AKP and MA (Moulin et al., 2005) had marked false recognition effects in both their judgements of fame and their judgements of repetitions. By contrast EN showed a false recognition effect only for episodic familiarity (repetition) but not for semantic familiarity (fame). It is interesting to note that EN (unlike AKP and MA) does not experience déjà vécu in relation to people and faces in everyday life. Therefore it initially seems surprising that he shows such a pronounced false repetition effect for faces. However this

experiment involves viewing images of faces, rather than real life encounters with people. As such it is more similar to watching television than experiencing an autobiographical event, and may therefore reflect his déjà vécu more closely than it might first appear. This distinction between personally experienced, autobiographical episodes and non-personal episodes is explored further in the discussion.

### *iii) Recollective Experience Task*

Moulin et al. (2005) attributed déjà vécu in their two cases to overextended recollective experience, in which falsely recognised items and situations were “recollected” with the same detail as a genuinely remembered experience. This recollective experience differs from familiarity, which lacks the detail of recollection but is characterised by a more general feeling of having encountered the information before (Gardiner & Richardson-Klavehn, 2000, Yonelinas, 2002). Therefore a recollective task based on that described by Moulin et al. (2005) was administered in order to explore whether overextended recollective experience was also a feature of EN’s déjà vécu.

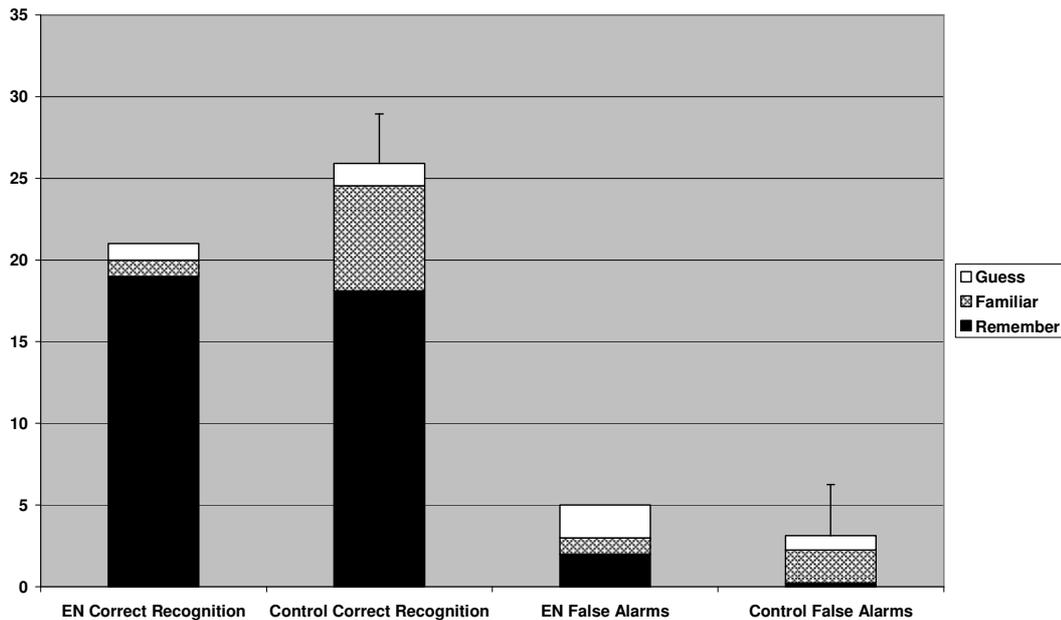
#### Methods:

Participants were presented with a series of 30 words. 10 of these words were low frequency (Kucera-Francis frequency = 1, e.g. “presage”), 10 were of mid frequency (Kucera-Francis frequency = 150-350, e.g. “heart”) and 10 were of high-frequency (Kucera-Francis frequency 500-1600, e.g. “good”, see appendix v for a full list of words used). Frequency information was obtained from the MRC

Psycholinguistic Database (Coltheart, 1981). This manipulation examined the possibility that *déjà vécu* may be more marked for distinct than mundane events (Moulin et al., 2005). Words were read out loud in a pseudo-random order and participants were asked to make a pleasantness judgement for each word (pleasant, unpleasant or neutral). Immediately afterwards the participants had a test phase in which the 30 original words were presented alongside 30 frequency-matched new words. Words were read out loud in a pseudo-random order and participants were asked to indicate whether the word was one of those from the original list. If they indicated that it was, they were asked to describe how “well” they remembered the word from the list by indicating whether their response was “remember”, “familiar” or “guess”.

The same instructions given by Moulin et al. (2005) were used to explain the different memory awareness states to participants. The three response categories were also presented on a card to which they could refer throughout testing. The categories were: “Remember: this is one of the words I heard before. I can remember hearing it. It has a feeling of pastness. I can remember something about it when it was presented before. Familiar: This is one the words I heard before, it seems familiar to me. Guess: This is one of the words I heard before, but I’m guessing.” Following a *Remember* response, participants were asked to justify their choice by describing what it was they remembered about the word. Justification for *Familiar* and *Guess* responses was not requested.

Results:



**Figure 3: Correct recognition and false alarm rates on the Recollective Experience task, divided into *Remember*, *Familiar* and *Guess* responses.**

EN's rates of correct recognition and false alarms did not differ significantly from controls. Similarly there were no significant differences in the proportion of *R*, *F* and *G* responses assigned by EN to his responses compared to controls, for either correct recognition or false alarms. No effects of word frequency were found on rates of correct recognition or false alarms. EN made two false alarms in response to high frequency lures and three in response to mid-frequency lures. However, like controls, he made no false alarms to low frequency lures.

Patients AKP and MA made high numbers of false alarms on this task (including to low frequency words), and tended to provide "Remember" responses for them, leading Moulin et al. (2005) to conclude that an overextended recollective experience was a key feature of their *déjà vécu*. In contrast EN seemed well able

to distinguish previously encountered words from lures, and also had normal recollective experience. EN did tend to use a large number of *R* responses, however his justifications for these seemed appropriate. For example when justifying his *R* response for the presented word “presage” he responded “I remember I had to ask you to repeat this one”. EN did assign *R* responses to 2 of his false alarms (which are more normally associated with *F* responses, Gardiner & Richardson-Klavehn, 2000), and provided recollective confabulations to justify these responses (for example for the lure “field” he responded “I remember thinking of a cricket field”). However given that his rates of false alarms were low and within normal limits on this task, there is no evidence of generally over-extended recollective experience.

#### *iv) Source Monitoring Task*

One final possibility is that EN’s déjà vécu results from a source monitoring impairment. Source monitoring describes the attribution process by which current mental events are attributed to particular sources on the basis of their qualitative characteristics, such as perceptual, contextual, and semantic information (Johnson, Hashtroudi & Lindsay, 1993). It is possible that EN suffers from a particular type of source monitoring impairment in which he is unable to accurately evaluate the source of his memories. Many types of source monitoring impairment could be implicated in déjà vécu; one obvious candidate is an impairment in temporal source monitoring (i.e. memory for *when* events happened). In order to investigate this possibility a source monitoring test was

administered assessing memory for two types of source (temporal and person source) based on that developed by Waters, Maybery, Badcock & Michie (2004).

#### Methods:

Participants watched or performed pairings of two sets of 24 household objects over two sessions 30 minutes apart. In each session 24 objects (e.g. toy car, coin, etc) were randomly intermixed on a table top. Participants were told that they would pair some of the objects together and that the experimenter would pair other objects together, and that they would do this in two separate sessions. They were warned that they should try to remember which objects went together, who paired them, and in which session, for a subsequent memory test. The experimenter and the participant took turns to pair the objects, and instructions were read out loud by the experimenter (e.g. "I would like you to put together the cup and the key", "Now watch me put together the spoon and the button"). Five minutes after the second session the participants had a recognition test in which 24 object pairs were read out loud in a random order. 16 pairs were kept in their original combination and 8 pairs were objects that were re-paired in new combinations. No new objects were presented and objects in new combinations were kept within the same action sequence (watch/perform) and presentation session (1 or 2). Participants were asked to say if the pairs were pairs that had been made earlier, or if they were new combinations of objects. For those pairs which they indicated had been made earlier they had to specify who performed the pairing, (self/experimenter), and in which session the pair had been made (session 1/2). See appendix vi for a list of all stimuli.

Results:

**Table 3:**

*Source Monitoring Task. (\* = significantly different from control  $p < 0.05$ ).*

	<b>Control Mean</b>	<b>Control Std. Dev.</b>	<b>EN</b>
<b>Item Memory</b>			
Correctly recognised pairs (Max 16)	12.30	3.83	12
False Alarms (Max 8)	1.7	1.77	5
<b>Source Monitoring</b>			
Proportion Correct Person Source	0.96	0.05	0.58 *
Proportion Correct Temporal Source	0.85	0.17	0.50 *

EN's performance on the Source Monitoring task can be seen in table 3 alongside the performance of the control group. In terms of item recognition, EN's ability to correctly identify pairs which had been presented earlier was unimpaired. His false alarm rate (misidentifying re-arranged pairs as original pairs) was slightly raised but within normal limits.

However EN's source monitoring ability was dramatically impaired. Controls correctly identified whether they or the experimenter had made the pair 96% of the time, and correctly identified the session in which the pairing had been made in 85% of cases. However EN performed at chance levels when asked to make either type of source judgement, and his performance was significantly worse than controls in both categories (person source judgements:  $t = -7.25$ ,  $p < 0.001$ ; temporal source judgements:  $t = -1.963$ ,  $p = 0.04$ ). Despite intact item memory, EN is completely unable to accurately recall contextual information about the source of his memories.

## DISCUSSION

This study presents a unique case of déjà vécu. For 12 years, EN has had the experience that he has lived through events before. This differs from the typical déjà vu experience in which there is a general feeling that the event has happened at some unspecified point in “the undefined past” (Neppe, 1983). EN is completely convinced by his experience, cannot be reasoned out of the belief that he has seen these events before, and provides recollective confabulations to justify his beliefs. EN’s déjà vécu also has features not described previously in the literature: unlike previous cases, his déjà vécu is limited to non-personal events. By contrast he never experiences déjà vécu for personally experienced, autobiographical events. EN’s déjà vécu is also very specific in time: all events are thought to have been first experienced in 1994 in the period he spent in hospital immediately after his accident.

The key features of EN’s case will be discussed as follows: First, the cognitive mechanisms underlying EN’s déjà vécu are discussed and a theory of déjà vécu offered. Second, the unusual domain-specificity of EN’s déjà vécu is discussed, along with the implications for our understanding of normal memory. Third, the implications of these findings for cognitive rehabilitation of déjà vécu and related disorders are explored. Finally, the limitations of the study are addressed, and some speculations made about the neuroanatomical substrates of the déjà vécu experience.

### ***The Cognitive Mechanisms Underlying Déjà Vécu***

In Moulin et al.'s (2005) study, their two patients with déjà vécu showed a characteristic pattern of performance on experimental tasks. Their metacognitive abilities were intact. However a) they had high levels of false positives on a range of recognition tasks, b) they provided "Remember" responses for falsely recognised items, indicating overextended recollective experience, and c) they produced "recollective confabulations" to back these responses up, i.e. they provided (false) accounts of their prior experience of items and events. On this basis Moulin et al. (2005) distinguished between the normal experience of déjà vu and pathological déjà vécu by arguing that whilst déjà vu results from false familiarity, déjà vécu results from false recollective experience.

Similar to AKP and MA, EN was found to have intact metacognitive abilities in experimental testing – his déjà vécu could not be explained by a tendency to think that he knew everything. However the results from the other experimental tests showed a slightly different pattern of performance to Moulin et al.'s patients AKP and MA. In terms of false recognition EN had a normal false alarm rate for word recognition (in the recollective experience task) and for object pairs (in the source memory task). In the famous faces task his false alarm rate was also normal for semantic memory (fame judgements), but he had a very high false alarm rate in episodic memory (indicating repetitions of faces). In terms of recollective experience, EN did not show elevated "Remember" responses, indicating no evidence for overextended recollective experience. However the source memory task revealed a dramatic source monitoring

impairment, in which his ability to recollect source information was at chance, despite intact memory for the items themselves.

EN showed no evidence of extended recollective experience on the recollective experience task. This suggests that, in contrast to Moulin et al.'s (2005) account, *déjà vécu* in EN's case does not arise from generally overextended recollective experience. However EN did show an increased false alarm rate on specific tasks, raising the possibility that *déjà vécu* may arise from false familiarity.

The task on which EN showed the most marked impairment was the source monitoring task. On this task although he was as good as controls at recognising object pairs which had been made in the study session, he was at chance in his ability to identify a) whether it was him or the experimenter who had made the pairing, and b) which of two sessions the pair had been made in. In fact Moulin et al.'s (2005) patients also showed significant source monitoring impairments, even with a very easy source monitoring task (discriminating whether items had been presented in word or picture form), but this impairment was not raised in their discussion of the possible mechanisms underlying *déjà vécu*. A source monitoring impairment of this severity would mean that these patients, when they encounter something that feels familiar, have no supporting detail available to them about the source of this memory. A combination of false familiarity with a source monitoring impairment might therefore be the critical cognitive mechanisms underlying *déjà vécu*, and may be able offer an account of *déjà vécu* that applies to AKP, MA and EN.

***A two-factor theory of déjà vécu:***

Coltheart and colleagues (Coltheart, 2007; Coltheart, Langdon & McKay, 2007; Davies, Coltheart, Langdon & Breen, 2001; Langdon & Coltheart, 2000; Metcalf, Langdon & Coltheart, 2007, Turner & Coltheart, 2010) have suggested that delusions may result from a two factor impairment in which a first factor neuropsychological anomaly (which determines the broad type of delusion) is overlain with a second factor impairment in belief evaluation or monitoring processes. This second factor accounts for why the unusual belief is adopted and maintained rather than being rejected. Whilst the first factor will vary according to delusion type, the second factor may be common to all delusion types. This theory allows for the observation that many neuropsychological impairments associated with delusions may also be experienced *without* leading to a delusion (Davies et al., 2001).

This type of theory offers a means of understanding both déjà vu and déjà vécu. Both déjà vu and déjà vécu may result from the same “first factor” impairment: a false sense of familiarity (perhaps resulting from false activation of recognition memory systems located in the mesial temporal lobe, discussed further below). However if both déjà vu and déjà vécu arise from the same core deficit, how do they lead to such different disorders: one a normal and fleeting sensation experienced by approximately 60% of the population, and the other a delusional disorder? The two-factor account proposes that in order to create déjà vécu, the false feeling of familiarity must be combined with a second factor impairment in which belief evaluation or monitoring processes are faulty. Thus in déjà vu one has a strong sense that the familiarity is inappropriate and that one cannot

really have experienced this situation before. However in déjà vécu, false familiarity is overlaid with a failure in belief evaluation or monitoring processes, which renders the patient unable to reject their false beliefs.

The second factor belief evaluation or monitoring deficit has been proposed to be shared with other conditions involving false beliefs (Davies et al, 2001), and is likely to involve several components (Turner & Coltheart, 2010). However in déjà vécu, source monitoring impairments, and particularly temporal source monitoring impairments, may be a critical feature. A false sense of familiarity, for which you cannot identify the source, would give rise to the sensation of déjà vu (Brown, 2003). However a source monitoring impairment in which the sense of familiarity is inappropriate, and strongly linked to source information that is incorrect, would lead to a delusional proposition about the source of the familiarity, i.e. that you have experienced it before. In EN, his poor source monitoring seems to be combined with a bias to temporally place events in 1994. This may be because when he experiences a false sense of familiarity, the period of the accident (a very significant event in his past, when he also suffered a long period of PTA), offers the most obvious explanation, and because his memory impairment means that details of events encountered since 1994 are vague. In combination with other types of belief evaluation impairment, such as impairment of the ability to assess the plausibility of the belief in relation to other knowledge, this could lead to the adoption and maintenance of a delusional belief.

Most normal déjà vu experiences are unpredictable and fleeting, making empirical study difficult. However Kalra, Chancellor & Zeman (2007) reported an intriguing case of sudden onset déjà vu in a woman taking 5-hydroxytryptophan for a medical complaint. Forty-five minutes after taking the tablet the patient was overwhelmed with feelings of déjà vécu which lasted several hours. The same thing happened again on second administration for the drug. The paper contains a fascinating passage in which the patient describes her experience in detail. She comments at one point “I was a little freaked out when I watched TV as I felt I was watching repeats, although I knew I wasn’t, as it was the news”. Later she comments “I knew I couldn’t know these things, but I felt like I did.” (Kalra et al., 2007, p312). This paper seems to describe the first factor impairment of déjà vécu, without the second factor impairment. In this case, although disturbed by the intensity of her feelings of déjà vu, the patient was able to reason that the sensation of having lived through the present moment before could not be real.

To summarise, a two factor theory of déjà vécu would propose that the experience arises initially from a false sensation of familiarity (the first factor impairment). In normal cases this is fleeting, and addressed by intact source monitoring and reasoning processes, leading to a feeling of déjà vu. However in déjà vécu this experience is prolonged. Due to the additional presence of source monitoring and other belief evaluation impairments (the second factor), a recollective confabulation is generated about the source of the familiarity, leading to the delusional form of déjà vécu.

***Domain specific déjà vécu: A dissociation between autobiographical and non-autobiographical episodic memory processing?***

The most striking feature of EN's déjà vécu is that it does not affect all domains of memory. The patients described by Moulin et al. (2005) experienced déjà vécu across the board, for news events but also for personally experienced events. In sharp contrast, EN only experiences déjà vécu for news and sporting events, most often encountered on television. He has never experienced déjà vécu for personally experienced events. It appears that in EN, personal events may somehow be protected from the delusional process. If so, the current findings could have implications not only for our understanding of déjà vécu, but also for our understanding of normal memory.

Tulving and colleagues (Tulving 1972, 1983, 2002; Wheeler, Stuss & Tulving, 1997) have famously distinguished between episodic and semantic memory systems. Semantic memory describes the store of generic knowledge we have about the world, about facts, people and events, which lack accompanying knowledge of an individual episode in which the info was learnt. We simply "know" these things without recollecting an episode in which we learnt them. In contrast episodic memory uniquely enables us to remember past experiences - for example when we recollect what we had for breakfast this morning, or the events of our first day at school many years ago, we are using the episodic memory system. There is substantial evidence from the neuropsychological literature that these memory systems are dissociable. Thus most patients with amnesia have great difficulty recollecting events from their personal past, but have intact semantic knowledge of facts, meanings and events (see Kapur, 1999

and Wheeler & McMillan, 2001, for reviews). More rarely, the opposite pattern can also be seen, in which there is preserved memory for episodes but impaired memory for semantic knowledge (Markowitsch, Calabrese, Neufeldt, Gehlen & Durwen, 1999).

However the dissociation shown by EN is not as simple as an episodic / semantic distinction. EN's *déjà vécu* is restricted to news events, which may on the surface appear to relate to semantic knowledge, but they are in fact episodes. This is so for several reasons. First, the memories he has are time-specific: EN (falsely) recalls individual episodes in which he first encountered these news events on television in 1994 in Sydney, he does not recall generalised semantic knowledge of a fact. Second, his *déjà vécu* occurs when he experiences these events for the first time (he just doesn't believe that this is so), so by definition they relate to episodes. Third, it has been demonstrated that EN does not experience *déjà vécu* for general semantic knowledge. The Feeling of Knowing task demonstrated that he has no general feeling that he knows facts that he doesn't, and the Famous Faces task demonstrated that his false alarm rate for semantic (fame) information was normal. EN's *déjà vécu* only affects episodic memory. But more specifically, EN's *déjà vécu* affects only non-autobiographical episodic memory, that is events that he is not personally involved in.

The fact that EN never experiences *déjà vécu* for personally experienced events suggests the possibility that autobiographical and non-autobiographical episodic memories are processed differently, allowing for one domain to be

disrupted and the other to remain intact. No dissociation between these two forms of memory has been reported previously in the literature. But how might this three-way distinction, between semantic, autobiographical episodic, and non-autobiographical episodic memory, be explained? One argument would be that there are in fact three separate memory systems rather than two. However a single dissociation is not sufficient evidence to propose a third system, and the ability to remember both individual autobiographical and individual non-autobiographical episodes is well captured by the concept of episodic memory. Nonetheless EN provides evidence that these types of memory may dissociate. EN's episodic memory is damaged, but something is protecting autobiographical episodes from being disrupted, whilst leaving non-autobiographical episodes vulnerable to *déjà vécu*.

What is it that protects EN's autobiographical episodic memory from *déjà vécu*? Some clues may come from his performance on the experimental tasks. In these tasks his memory was largely preserved, and he very rarely showed false alarms, which would be expected if he was experiencing *déjà vécu* for the items. Therefore it is of value to examine the characteristics of these tasks which may have protected his memory from errors. In the Recollective Experience task EN showed a normal hit rate and a normal false alarm rate. One of the features of this task was a deep encoding manipulation during initial exposure to the words, in which he was required to make a pleasantness judgement about each item. It is likely that making a pleasantness judgement encouraged EN to encode these words in terms of associations that were of personal relevance. Indeed this is what he reported when justifying his *R* responses. The personal and

emotional associations he made with each word appeared to protect him from making high numbers of false alarms. Similarly in the Source Monitoring task, EN either paired objects together himself or watched a real other person make the pairings. Again his false alarm rate was within normal limits, which may be secondary to his personal involvement in the procedure. The only task in which he showed an elevated false alarm rate (and in this case his false alarm rate was dramatically high) was the Famous Faces task. In this task he was exposed to a series of photographs with which he did not interact personally, and for which he did not complete an encoding task encouraging him to make personal or emotional associations.

These tasks seem to mirror very well the real life situations for which EN does and does not experience *déjà vécu*. Situations with which he is personally involved, for example pairing objects, meeting someone, or going somewhere for the first time, are associated with personal actions, thoughts and emotional content. As such they are salient experiences, and are not associated with false alarms or *déjà vécu*. However in non-personal, passive situations such as watching TV, or viewing a series of photographs, the personal and emotional associations are reduced. In these cases EN seems unable to overcome his feelings of familiarity. This familiarity may be enhanced because these types of events (watching TV or images) are very similar to each other (they share “single element familiarity”; Brown, 1993; Whittlesea & Williams, 1998) and therefore arouse more familiarity than autobiographical events which have personal and emotional context identifying them as unique. In EN, autobiographical or personally experienced events appear to be protected by

the salience afforded by their emotional and personal associations, leaving only non-autobiographical episodes vulnerable to déjà vécu.

This account fits well with Conway's "Self Memory System" (Conway, 2001, 2005; Conway & Pleydell-Pearce, 2000). In this theory autobiographical memories are created when episodic memories (defined as detailed but short-lived sensory-perceptual records of an experience) become integrated with the autobiographical memory knowledge base. Only once this consolidation has occurred do they become long-lasting autobiographical memories which are then retrieved with recollective experience. In EN, personally experienced events seem to undergo this consolidation appropriately, but news and sporting events, for which he experiences high levels of familiarity without the personal and emotional associations which would identify them as unique, become inappropriately linked with one single aspect of his autobiographical knowledge base: his 1994 stay in hospital. Having been incorrectly associated with this autobiographical event, novel news and sporting events are then experienced as if they were autobiographical memories, with false recollective experience.

***Implications for the rehabilitation of déjà vécu and related disorders:***

EN suffers from memory impairment. Part of this impairment is of the type that cognitive rehabilitation professionals are familiar with, namely impairment in forming new memories (anterograde memory impairment), as demonstrated by his performance on standardised memory testing. However his presentation involves not only the *absence* of memories, but also the *presence of false* memories, in the form of déjà vécu. Traditional forms of memory rehabilitation

(such as mnemonics, spaced retrieval, vanishing cues, errorless learning and external memory aids), are designed to compensate for disorders involving the absence of memory, but not to correct for the presence of false memories, leaving a gap in our knowledge about how to rehabilitate this type of memory disorder.

In order to develop rehabilitation programs for memory disorders, we need a thorough understanding of the cognitive mechanisms that underlie them. If we can precisely identify the nature of the impairment, this gives us clues about possible approaches to improve performance (Ptak, der Linden & Schnider, 2010). If the account of *déjà vécu* offered here is correct, it carries implications for the rehabilitation of *déjà vécu* and related disorders. Whilst it may not be possible to directly affect the false feeling of familiarity that EN experiences for novel stimuli (the first factor), it may be possible to address the monitoring impairments which overlie this (the second factor). One possibility would be to directly target EN's source monitoring impairment. This might include increasing his awareness of the source monitoring process, so that he might learn to differentiate those features associated with genuine memories from those associated with the *déjà vécu* experience. This would be an internal intervention, and rely quite heavily on insight and intact reasoning skills. An alternative approach would be to try and implement external aids to source monitoring. For example EN might be encouraged to find supporting evidence for a memory in the form of external accounts or records, that backed up his sense that the information had been encountered before. Other interventions targeted at second factor monitoring impairments might include capitalising on

EN's remaining intact reasoning abilities to reason about his experience, question the evidence, and evaluate the plausibility of his "memories" (perhaps using a Theory A vs. Theory B intervention). As well as targeting the déjà vécu experience after it has occurred, it may be possible to reduce the frequency of EN's déjà vécu by avoiding the types of experience that are most likely to trigger it. If it is true that the formation of personal and emotional associations with an event protect EN's episodic memories from déjà vécu, then encouraging him to encode new events in this way might reduce the occurrence of the déjà vécu experience.

In addition to interventions directly informed by the experimental results presented here, other general rehabilitation strategies might be useful in managing déjà vécu and related disorders. Very few published papers describe rehabilitation of paramnesic conditions. However those that do describe a critical role for increasing awareness of the deficit as a first step in the rehabilitation program (DeLuca, 1992; DeLuca & Locker, 1996). This might include psychoeducation about the potential role of brain injury in false feelings of familiarity. Dayus & van den Broek (2000) have reported successful use of self monitoring training (also based on increased awareness) to reduce delusional confabulations. However it is possible that this type of intervention may reduce the outward expression of false beliefs whilst not affecting their actual occurrence. Some authors also suggest correction of the false belief (Del Grosso Destreri et al., 2002). In previous studies of rehabilitation of paramnesias this has been successfully achieved by having the patient keep a memory notebook or diary in which they record daily events, and which they

can refer back to in order to disconfirm their erroneous memories (Burgess & McNeil, 1999; del Grosso Destreri et al., 2002; Yamamoto, Izumi, Shimakura, Sawatari & Ishida, 2000). Unfortunately in EN's case, a diary intervention would be unlikely to work, because all of his déjà vécu experiences are attributed to 1994 (a period for which no diary of events is available), but it may be a useful intervention in other cases where the incorrect attributions are not time-specific. However caution should be exercised in directly confronting or challenging incorrect beliefs, as in déjà vécu and other paramnesias the false beliefs are generally held with considerable conviction and form the basis of the patient's subjective reality. Confrontation that is not managed sensitively may cause anxiety and lead to resistance and breakdown of the therapeutic alliance (Fotopoulou, 2010; Glowinski, Payman & Frencham, 2008).

In general, errorless learning principles suggest that best practice would be to limit the number of occasions on which EN has a déjà vécu experience (Ptak et al. 2010), as the repeated process of falsely recalling an earlier encounter with the information will reinforce the false memory and make it more likely to be recalled in future. For the same reasons, Hinkebein, Callahan & Gelber (2001) recommend minimising discussion of the inaccurate memories to avoid inadvertent reinforcement.

### ***Limitations of the Study***

One weakness of the current study is that no contemporary brain imaging was available for EN. Whilst CT reports from the time of his injury indicated a severe head injury involving combined hypoxic and diffuse axonal damage, and a

depressed fracture of the left frontal bones, there is unfortunately no information about the specific brain regions that showed most damage, nor about the pattern of injury that was evident 12 years post-injury at the time this study was undertaken.

The available evidence gives reason to expect that EN's impairments would have been associated with damage to the mesial temporal and frontal lobes. The mesial temporal lobe is known to be critically involved in memory (Aggleton & Brown, 1999). It is also known that temporal lobe epilepsy can give rise to sensations of *déjà vu*, indeed *déjà vécu* is part of the "dreamy state" associated with epilepsy (Jackson, 1931), and studies of the dreamy state using both cortical stimulations and spontaneous epileptic seizures have consistently associated *déjà vécu* experiences with electrical discharges localised within the mesiotemporal and limbic structures (Bancaud, Brunet-Bourgin, Chauvel & Helgren, 1994; Bartolomei, Barbeau, Gavaret, Guye, McGonigal, Regis, & Chauvel, 2004; Vignal, Maillard, McGonigal & Chauvel, 2007; Weinand, Hermann, Wyler, Carter, Oommen, Labiner, Ahern & Herring, 1994). The sense of false familiarity associated with *déjà vécu* has therefore been hypothesised to arise from false activation of recognition memory systems located in the mesial temporal lobe (Moulin et al., 2005; Spatt 2002)

The idea that frontal regions should be involved in *déjà vécu* also fits well with current knowledge. The prefrontal cortex is known to be critically involved in control of memory processes (Fletcher & Henson, 2001; Moscovitch & Winocur, 2001; Petrides, 2000), including strategic memory retrieval and the monitoring

of memory output for accuracy (Burgess & Shallice, 1996, Henson, Shallice & Dolan, 1999; Moscovitch & Melo, 1997; Schacter, Norman & Koustaal, 1998; Shallice, 2006; Stuss & Alexander, 2007). The prefrontal cortex is also thought to be critically involved in source monitoring, including retrieval of temporal source information about when an event took place (Cabeza, Locantore & Anderson, 2003; Daum & Mayes, 2000; Milner, Petrides & Smith, 1985; Johnson, 1997; Turner, Simons, Gilbert, Frith & Burgess, 2008). These are all processes assumed to be involved in the “second factor” ability to evaluate ones beliefs.

Consistent with this explanation, previous patients with *déjà vécu* have had frontal and temporal involvement. Patients AKP and MA had diffuse temporal damage and MA had additional frontal atrophy (Moulin et al., 2005), Tabet & Sivaloganathan (2001) reported a case of *déjà vécu* with a high density mass lesion in right frontal lobe, and Ide, Mizukami, Suzuki & Shiraishi (2000) reported persistent *déjà vécu* in a patient with abnormalities in the right fronto-temporal region.

A further potential weakness of this study was the range of measures employed. Measures were selected in advance to test hypotheses derived from the work of Moulin et al. (2005). However if further testing with EN had been possible, the existing results indicate that at least two further measures would have been of interest. First, it would have been desirable to assess recollective experience for additional stimulus types. The existing recollective experience task assessed whether EN produced abnormal number of false positive responses associated with “Remember” responses in word recognition. He did not. However it is

possible that EN would have shown evidence of overextended recollective experience for stimuli more closely related to the domain of his *déjà vécu*. In other words, we cannot be certain that EN did not have overextended recollective experience without assessing the rate of Remember responses for stimuli that did trigger false recognition (e.g. repetition of faces in the famous faces task, or news and sporting events).

To further test the hypothesis that EN had disruption to “second factor” belief evaluation processes it would also have been interesting to assess a wider range of reasoning and monitoring processes than just source monitoring. These might have included reality monitoring, plausibility judgements, and logical reasoning. Finally, greater attention to the wider clinical picture surrounding EN’s case would have been desirable. The measures selected focused on memory processes that were predicted on a theoretical basis to be involved in *déjà vécu*. However assessment of EN’s mood and pre-morbid personality style, as well as exploration of additional factors that may have motivated or maintained EN’s *déjà vécu*, would have enabled a full formulation of his individual case. All of these issues are explored further in the critical appraisal.

Finally some comment should be made about the utility of single case approaches in neuropsychology. On one hand, single case studies allow us to look in detail at unusual conditions such as *déjà vécu* and experimentally explore potential cognitive mechanisms in cases where it is not feasible to use group studies. The single case approach is particularly valuable in cases like EN who present with features not described previously in the literature. His case

also adds important information about the aetiologies associated with déjà vécu. EN is the first case to be reported where déjà vécu resulted from traumatic brain injury, whereas previous cases were associated with dementia (Moulin et al., 2005), tumour (Tabet & Sivaloganathan, 2001) or meningitis (Ide et al., 2000). On the other hand, a limitation of the single case approach is that the findings derived from EN may not generalise to other patients with déjà vécu. Indeed he showed a different pattern of performance from the patients presented by Moulin et al. (2005).

### ***Conclusions***

This study has presented a case of déjà vécu. Unlike previous cases described in the literature, EN's déjà vécu is limited to non-personal events (mainly news and sporting events) and is also very specific in time (all events are thought to have been first experienced in a single period in 1994). EN's déjà vécu was associated with an elevated false alarm rate in specific circumstances. It was also associated with a severe source monitoring impairment. On the basis of these cognitive impairments a two factor theory of déjà vécu has been proposed in which false familiarity for particular episodes (resulting from mesial temporal lobe dysfunction) is overlain with impairments in frontally located belief evaluation and monitoring processes, which allow recollective confabulations to be produced and not rejected. On the basis of the current data, at least one component of the belief evaluation impairment in déjà vécu is a deficit in source monitoring. It is proposed that the dissociation between autobiographical and non-autobiographical episodic memory processing in EN may be secondary to differences in the degree to which personal and emotional

associations are formed for these two different types of event. An understanding of the cognitive mechanisms underlying neuropsychological impairments is critical for the formulation of appropriate rehabilitation strategies. On the basis of the current results some preliminary options for rehabilitation of déjà vécu have been proposed. However further research on rehabilitation approaches for paramnesic conditions is required.

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## **PART THREE: CRITICAL APPRAISAL**

The study reported here is in the form of a traditional neuropsychological case study. The aim of these studies is to inform either our understanding of the normal operation of the cognitive function studied (in this case, memory), and/or to inform our understanding of how to rehabilitate the condition described. To what extent has the current study achieved either of these objectives?

*Implications for the Understanding of Normal Memory Function:*

In terms of our understanding of normal memory function, the greatest contribution of the current study is the demonstration of a dissociation between autobiographical and non-autobiographical episodic memory processing. This is the first time such a dissociation has been reported, and indicates that the two types of memory may be processed differently in the normal brain. Dissociations are important in cognitive neuropsychology. A dissociation alone is insufficient to conclude that the two processes are functionally separate in terms of cognitive architecture (i.e. that there are two systems, one for autobiographical episodic memory and one for non-autobiographical memory). For that we would need a double dissociation (i.e. reports of patients with preserved non-autobiographical episodic memory processing, but impaired autobiographical memory processing, see Shallice, 1988). However a dissociation does indicate at the very least that these two forms of memory are processed differently in some way, such that one can be disrupted whilst leaving the other intact. On the basis of the current data, a preliminary explanation has been offered in terms of differences in the degree to which personal and emotional associations are formed for these two types of event. Greater personal and emotional associations, it is argued, protect autobiographical episodic memories from false feelings of familiarity, but leave non-autobiographical episodic

memories vulnerable to disruption. However further research is clearly necessary to evaluate whether this explanation is able to account for the data. One direct way of doing this would be experimentally manipulate the personal and emotional associations that EN made for different types of memory, and observe the impact on his experience of déjà vécu. Other avenues of research might include using the “dreamy state” associated with temporal lobe epilepsy as a model. Vignal, Maillard, McGonigal, & Chauvel (1994) reported the intriguing finding that in their study of the dreamy state, all patients who experienced involuntary memory recall during stimulation or spontaneous seizure recalled an event from episodic memory; none recalled a public or historical event from semantic memory. It would be interesting to further explore this pattern in terms of recall of autobiographical versus non-autobiographical events. Also of interest to the current case is Vignal et al’s finding that although the memories evoked differed on each occasion, they were drawn from the same period of the subject’s life (this observation applied to all subjects except one). This temporal consistency is reminiscent of EN’s tendency to attribute all of his déjà vécu experiences to the same time period in 1994. It may be that study of the dreamy state could shed further light on the characteristics of the delusional déjà vécu experience and its underlying cognitive mechanisms.

The study also has the potential to tell us something about the way the normal brain processes familiarity and recollection, regardless of whether this is in autobiographical episodic memory, non-autobiographical episodic memory, or both. The study followed the example of Moulin, Conway, Thompson, James & Jones (2005) in attempting to break down a cognitive disorder into its component cognitive

mechanisms, by experimentally assessing a range of cognitive functions thought to be theoretically involved in déjà vécu. This type of study has the potential to move us beyond simple descriptive accounts of syndromes and towards a fuller understanding of how cognitive disorders might arise (and also therefore, how they might be rehabilitated). The current study partially replicated Moulin et al.'s (2005) results. It confirmed that for EN, as for AKP and MA, déjà vécu does not arise from generally disordered metacognitive abilities, but that it is associated with false recognition (in the form of false alarms to certain types of stimuli) and source monitoring impairments. However the current study did not replicate Moulin et al.'s (2005) finding that déjà vécu was associated with overextended recollective experience. On the basis of these results an account was proposed suggesting that false activation of the networks responsible for the normal feeling of familiarity may give rise to both déjà vu and déjà vécu. The difference between the two, on this account, is the normal or otherwise operation of processes responsible for belief evaluation and monitoring. This account is of course preliminary. However it does incorporate both of the cognitive impairments revealed in experimental testing (disordered recognition and source monitoring impairments) and is also in line with wider theories about the mechanisms responsible for delusional beliefs (Davies, Coltheart, Langdon & Breen, 2001).

This account is in contrast, however, to that of Moulin et al. (2005), who argue that whilst déjà vu is a disorder of familiarity, déjà vécu is a disorder of recollection. One weakness of the current study is the extent to which we can be confident in ruling out their account. EN did not show overextended recollective experience in the “recollective experience” task. However he also did not show elevated false alarms

in this task. This raises the possibility that if we had assessed recollective experience for items for which EN did produce false alarms (repetition of faces in the “famous faces” task, for example), we may in fact have seen evidence of overextended recollective experience. This is certainly a limitation of the study. However even if we had observed overextended recollective experience it would have been difficult to conclude that it represented a separate process to that responsible for false familiarity. In other words, false recollection may arise quite separately from familiarity, or it may result from a feeling of false familiarity which is then justified by the production of a confabulated account of when the item was encountered. These two possibilities are very difficult to pick apart. Indeed this problem lies at the heart of the ongoing debate about whether recollection is simply a stronger, more vivid version of familiarity (the single process account of recognition) or whether recollection and familiarity represent separate processes (the dual process account, see Squire, Wixted & Clark, 2007, and Mandler, 2008 for reviews). On the basis of the evidence available for EN, an account in terms of familiarity seems at present to be the more parsimonious option. However it would certainly have been desirable to further explore EN’s recollective experience with a greater range of stimuli.

Unfortunately the current study was not able to inform our understanding of brain-behaviour relationships, as neuroimaging was not available for EN. However, some speculations have been made on the likely neuroanatomical basis for déjà vécu (medial temporal and frontal), and whilst knowledge about the neural basis of behaviour is certainly interesting, theoretical inferences about cognitive architecture may be made in the absence of knowledge about localisation (Coltheart, 2006). Future research using both structural and functional imaging techniques may be able

to confirm or refute the proposed neuroanatomical basis of déjà vécu, and perhaps also shed light on differences in activation associated with autobiographical and non-autobiographical episodic memory.

*Implications for Rehabilitation of Déjà Vécu and Related Disorders:*

Paramnesias have been largely ignored in the rehabilitation literature, in favour of interventions for the amnesias. In part, this is because conditions such as déjà vécu, reduplication and confabulation are rare, and tend to resolve spontaneously after a few months. Indeed only a handful of cases of déjà vécu have been reported in the literature. However this case highlights the fact that there are cases where paramnesic experience can persist and become delusion-like in intensity, posing a significant rehabilitation problem. Déjà vécu also bears several similarities to other forms of confabulation and delusion, meaning that rehabilitation approaches developed for one disorder may also be applicable to the others.

A critical task in developing rehabilitation approaches for paramnesic conditions is to establish the cognitive mechanisms responsible, and target these mechanisms in rehabilitation (Ptak, der Linden & Schnider, 2010). In the empirical paper some suggestions were made about potential rehabilitation approaches that might target the cognitive mechanisms identified in this study. As it seems unlikely that one would be able to directly target the false feeling of familiarity, these mainly focused on “second factor” belief evaluation and monitoring processes, for example implementing procedures that would compensate for EN’s source monitoring impairment, or capitalise on his intact reasoning and evaluation processes to evaluate his experiences. The earlier discussion also highlighted the importance of raising

awareness of impairment as a first step to rehabilitation, and (in line with errorless learning principles), of avoiding the déjà vécu experience arising at all where possible, perhaps by encouraging the formation of personal / emotional associations with new memories. Unfortunately there would be limited application for the use of external aids in this case, as EN's déjà vécu was unusually specific in time, with all events being attributed to 1994, a period for which no external record of events was available to consult. However in other cases of paramnesia, external aids which allow a record of past events to be accumulated (such as diaries or SenseCam) might be useful in providing a means of checking memories.

Finally, the similarities between paramnesic conditions such as déjà vécu and delusions raises the possibility that interventions designed for delusions in the context of psychiatric disorders might be effective for cases like EN. Elements of CBT for psychosis, for example, might have some application, perhaps including reality testing or thought challenging work (Nelson, 2005), exploring conviction in beliefs, or Theory A vs Theory B interventions (comparing the possibility that you have lived through the current moment before, to the possibility that feelings of familiarity have been disrupted in some way by head injury). As with other types of delusions, EN's déjà vécu is experienced as incontrovertibly "true", meaning that any direct challenging of beliefs would need to be conducted sensitively.

The current study therefore raises several possibilities for rehabilitation, and this is a strength of studies that attempt to analyse in detail the cognitive mechanisms involved, rather than simply describe a phenomenon. However it is a limitation of the study that we were not able to attempt any of these rehabilitation techniques with

EN. Preliminary data on how he responded to various interventions would not only have enabled a test of the account of déjà vécu offered, but would also have offered valuable information on which, if any, of these approaches might be effective for the rehabilitation of this and other paramnesic conditions.

*Limitations of the current study:*

Two additional limitations of the current study were touched upon in the empirical paper which deserve further comment here. Firstly, the inclusion of additional measures would have been desirable if further testing opportunities with EN had been available. The measures included were able to reveal some interesting results and dissociations. However as mentioned above, further measures assessing recollective experience in different domains would have been desirable. In addition, to further test the hypothesis that EN had disruption to “second factor” belief evaluation processes, it would have been interesting to assess a wider range of reasoning and monitoring processes than just source monitoring. These might have included reality monitoring, plausibility judgements, and logical reasoning. In general, further attention might also have been paid to the ecological validity of the measures employed. Some of the experimental tests were rather dry, and measures which better captured the essence of EN’s experience (for example the experiential quality of TV or news events, or of real-life autobiographical events) might have been able to model the circumstances which gave rise to (or did not give rise to) his déjà vécu experiences more closely.

Secondly, greater attention to the wider clinical picture surrounding EN's case would have been desirable. The focus on cognitive neuropsychological measures and models meant that formulation of personal historical and psychological factors received less attention. EN's early experiences, pre-morbid personality characteristics, current situation, and mood, whilst not causing his *déjà vécu* per se, will have interacted with his neurological insult to produce the particular flavour of his false beliefs, and further attention to these may have uncovered factors involved in motivating or maintaining EN's *déjà vécu*.

There has been increasing interest in the role of motivational factors in confabulation and delusion (e.g. Fotopoulou 2010; McKay & Kinsbourne, 2010), and the potential role that confabulation might play in making the world a more pleasant or controllable place, in extremely difficult circumstances. It may be that some people are more liable to confabulatory compensatory mechanisms than others, for example to maintain a sense of self or a sense of mastery in a situation that is otherwise characterised by confusion, impairment and uncertainty. EN's tendency to attribute all events to 1994, for example, may be related to the fact that this was a particularly traumatic period. Along these lines, the delusion interview revealed the intriguing presence of an isolated paranoid belief about his brother. The source of this would have been interesting to explore. Paranoid beliefs following brain injury have been interpreted as a means of reasserting one's own importance when other people's behaviour towards you is changing, and as the product of disordered conceptual ability in interpersonal situations, and changing social roles (Leftoff, 1983). It is very likely that EN's change in role from a successful young man with a

promising future, to an impaired 38 year old living with his father, would have had a significant impact on his adjustment and coping mechanisms, and therefore upon the particular characteristics of his déjà vécu presentation.

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## **Appendix i: Delusion Interview**

### **Orientation to situation:**

Why are you here today?

Have you recently been unwell / had to go to hospital for any reason? (When? What?  
Ask for full details)

Did you have any surgery or treatment for this?

Are you having any treatment or seeing anyone for help with anything at the moment?

Why are we interested in seeing you?

### **Effect of illness:**

#### **If illness / accident acknowledged:**

Tell me about how your illness / accident has affected you.

Have you had any difficulties since your illness / accident, or found that you cannot do things you used to be able to do?

Have you experienced things since your illness / accident that you did not experience before?

Has your illness / accident changed you or the way you think in any way at all?

Have you felt confused since your accident?

Do things ever feel unreal or like a dream?

#### **If illness / accident not acknowledged:**

Have you had any difficulties recently or found that you cannot do things you used to be able to do?

Have you experienced things recently that you did not experience before?

Have you felt confused?

Do things ever feel unreal or like a dream?

### **Orientation in time:**

What year is it?

What season are we in?

What month is it?

What day is it?

What is the date?

**Orientation to place:**

Where are we now? (Which centre / hospital)

Which floor are we on?

Which city / town are we in?

Which suburb / area are we in?

Which state / country are we in?

**Reduplicative paramnesia:**

Have you been here before?

How many centres / hospitals with this name are there?

Who am I?

Have you seen or met me before?

Have you known any of the other people here previously?

Do you know anyone else with your illness?

Have you had any similar illnesses or treatment in the past? / How many accidents / operations have you had?

**Delusion Battery:**

**Some people have experiences which are unusual or troubling after head injury / illness. I'm interested in finding out whether you have experienced any of these.**

Hallucinations (all from SAPS):

Have you ever heard voices or other sounds when no one is around?

If so: What did they say?

Have you ever had burning sensations or other strange feelings in your body?

If so: What were they?

Have you ever experienced any unusual smells or smells that other people do not notice?

If so: What were they?

Have you ever had visions or seen things that other people cannot see?

If so: What did you see?

Did this occur when you were falling asleep or waking up?

Schizophrenia-type Delusions (all from SAPS or PDI):

Have you felt that people are against you, trying to monitor you, or trying to harm you in any way? (Persecutory delusions)

Do you have a partner? Are you often worried that your partner might be unfaithful to you? (Delusions of jealousy)

Do you ever feel that you have done more wrong than the average person, or deserve to be punished? (Delusions of sin or guilt)

Do you have any special or unusual abilities? Or do you feel that you are destined to achieve great things? (Grandiose delusions)

Have you had any unusual religious experiences or felt particularly close to God? (Religious delusions. If present, check religious background).

Is there anything wrong with your body or have there been any unusual changes to do with your body? (Somatic delusions)

Do you ever feel that things in magazines or TV were written specifically for you, or contain messages specifically for you? (Ideas and delusions of reference)

Have you felt that you were being controlled by some outside force? (Delusions of being controlled)

Have you ever had the feeling that people could read your mind? (Delusions of mind reading)

Have you ever heard your own thoughts out loud as if they were a voice outside your head? Have you ever felt that your thoughts were broadcast in some way so other people could hear them? (Thought broadcast)

Have you ever experienced thoughts that didn't seem to be your own, or felt that thoughts were being put into your head by some outside force? (Thought insertion)

Have you ever felt your thoughts were taken away by some outside force? (Thought withdrawal)

Cotard

Do things ever seem very unreal to you?

Do you ever feel that you do not really exist?

Do you ever feel that you have died?

De Clerambault

Have you felt that anyone has become very interested in you, or fallen in love with you?

General misidentification question

Do you ever feel as if some people are not who they appear to be?

Capgras

Do you ever feel that people around you have been replaced by someone else?

Fregoli

Do you ever feel that people around you are in disguise?

Intermetamorphosis

Have you ever felt that someone you know has been transformed into someone else?

Reduplicative paramnesia

Do you ever feel that several people exist who are very similar or identical?

Do you ever feel that several places exist that are very similar or identical, for example a hospital, house or other building?

Have you felt that any of your possessions have been replaced?

Have you ever felt that the same things have happened to you more than once?

Mirrored self misidentification

Practical test – hold up mirror and ask “who is this?”

Denial of ownership in neglect

This section administered *only* for patients with paralysis / neglect

Can you raise your left arm?

Is this your arm?

How many arms/legs do you have? (also reduplication)

## **Appendix ii: Confabulation Battery**

**I am going to ask you a few questions about yourself and about world events and general knowledge. Some of these are difficult or hard to remember, so if you don't know the answer to any question that is fine, just say you don't know. I would rather you didn't guess, so just tell me if you are sure.**

The following section consists of 10 personal semantic memory questions (5 current "CPS" and 5 remote "RPS"), 10 general semantic memory questions (5 current "CGS" and 5 remote "RGS"), 15 personal episodic questions (5 remote "RPE", 5 current "CPE", 5 future "FPE"), and 10 "Don't Know" questions (5 semantic "SDK" and 5 personal episodic "EDK")

How old are you? (CPS)

Tell me about a memorable birthday party or celebration you had when you were young (RPE)

Where is the river Boas? (SDK)

What happened to President Kennedy? (RGS)

Where were you born? (RPS)

What style were the shoes you wore in summer 1995? (EDK)

How did you spend last Christmas? (CPE)

Do you work at the moment? What is your job? (CPS)

What did you do this morning? (CPE)

Who won the AFL premiership last year? (CGS)

Do you have any children? How many? What are their names and ages? (CPS)

What are your plans for tomorrow? (FPE)

Who was Harold Holt? (RGS)

How old were you when you first used a telephone? (EDK)

What did your parents do for a living? (RPS)

What happened in Bali last year? (CGS)

Tell me about a childhood holiday you remember going on (RPE)

Do you have any trips planned for the next few months? When will your next holiday be? (FPE)

Who was Lindy Chamberlain? (RGS)

Where do you live? (CPS)

Who is Schapelle Corby? (CGS)

Are you married? Who to? (CPS)

How will you spend next Christmas? (FPE)

Who is the author of Black Snow? (SDK)

Tell me about your first day at high school (RPE)

What happened in Chernobyl? (RGS)

What were you doing on May 2<sup>nd</sup>, last year? (EDK)

How did you get here today? (CPE)

What are you doing when you leave here today? (FPE)

What is your date of birth? (RPS)

What happened with Princess Mary recently? (CGS)

Who is the current world-fencing champion? (SDK)

Where were you going on your first car journey of 2001? (EDK)

Who were the Beatles? (RGS)

Tell me about your first date (RPE)

How far did you get at school? What kind of education or training have you completed? (RPS)

What happened in New Orleans last year? (CGS)

Who is Stockhausen? (SDK)

Tell me about the closest friend you had in your teens. What did you do together? (RPE)

When was the Concorde's first flight? (SDK)

Do you have any brothers or sisters? What are their names? Are they older or younger? (RPS)

What did you do yesterday? (CPE)

What was your primary school teacher's favourite pet? (EDK)

When was the last time you were away from your home town? (CPE)

What will you be doing next year? (FPE)

## **Appendix iii: Dating Battery**

### **NEWS / SPORTS EVENTS**

#### **Pre-accident**

When did man first walk on the moon?	1969
When was the first world series cricket game held?	1977
When did John Lennon die?	1980
When did Ronald Reagan come to power?	1981
When did the Wallabies win their first Grand Slam title?	1984
When did Allan Border become captain of the Australian cricket team?	1984
When did the Berlin wall come down?	1989
When did David Boon drink 52 cans on a flight to London?	1989
When was Nelson Mandela released from prison?	1990
When did Shane Warne bowl the “Ball of the century” to Mike Gatting?	1993

#### **Post-accident**

When was the Port Arthur massacre?	1996
When did Princess Diana die?	1997
When was the Olympics held in Sydney?	2000
When did Donald Bradman die?	2001
When did the September 11 <sup>th</sup> attacks take place?	2001
When did Lleyton Hewitt win Wimbledon?	2002
When did Ponting take over from Waugh?	2002
When was Shane Warne suspended for failing a drugs test?	2003
When did the Asian tsunami happen?	2005
When did the London bombings happen?	2005

### **PERSONAL EVENTS**

#### **Pre-accident**

When did you fall off the horse that bolted?	1974
When did you and your Dad fall off the motorbike?	1975
When did you attend cricket school at the University of Sydney?	1980
When did your family buy the surfer’s paradise timeshare?	1983
When did you build the cubby house?	1984
When did you win “Junior cricketer of year”?	1985
When did you play in a cricket match against the Indian team?	1988
When did you write off your Holden Nova?	1990
When did you buy the PND store?	1990
When did your mother pass away?	1992

#### **Post-accident**

When did Tom get married?	1996
When did you drive to Mooree to see a friend?	1996
When did you travel to Sydney by train but got off early by mistake?	1996
When did you leave your car in Canberra?	1998
When did you first come to Macquarie University?	1999
When did you sell your red commodore?	2002
When did you move to your current address?	2003
When was your last visit to the Gold Coast?	2004
When was Rory Born?	2004
When did your Dad travel to New Zealand?	2004

## Appendix iv: Feeling of Knowing Task

### **PART A: RECALL SECTION:**

**Here are a series of general knowledge questions. Some of them are rather difficult.**

**If you know the answer I would like you to write it in the space provided. Please do not guess at this stage, but only write the answer if you are sure.**

**If you do not know the answer I would like you to circle one of the three options according to whether you think you would recognise the answer if I gave you four options.**

REMEMBER PLEASE DO NOT GUESS UNLESS YOU ARE SURE OF THE ANSWER. YOU WILL HAVE THE OPPORTUNITY TO CHOOSE FROM A LIST LATER ON.

#### **1) In which country did Chess originate?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

#### **2) Which system in the human body controls hormones?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

#### **3) Which US president was shot 5 days after the end of the American civil war?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later

- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**4) Which team sport has periods of play called 'chukkas'?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**5) Which language has the most native speakers?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**6) What device mixes air and petrol (gas) for the internal combustion engine?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**7) Which is the largest planet in our solar system?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer

C) I will have to guess

**8) What is the capital city of Norway?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

A) I am CERTAIN I will be able to recognise this answer later

B) I am quite sure I will be able to recognise this answer

C) I will have to guess

**9) In which country will the 2008 Olympic Games be held?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

A) I am CERTAIN I will be able to recognise this answer later

B) I am quite sure I will be able to recognise this answer

C) I will have to guess

**10) How many strings does a violin have?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

A) I am CERTAIN I will be able to recognise this answer later

B) I am quite sure I will be able to recognise this answer

C) I will have to guess

**11) What do we call a shape with 8 sides?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

A) I am CERTAIN I will be able to recognise this answer later

B) I am quite sure I will be able to recognise this answer

C) I will have to guess

**12) Who developed the theory of relativity?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**13) Which chemical element is represented by the symbol N?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**14) In which country is Mount Everest?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**15) On which continent is the Sahara desert?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**16) Which pop singer married British movie director Guy Ritchie?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**17) Who wrote Tess of the D'Urbervilles?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**18) Which rock group did George Harrison belong to?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**19) Who developed the theory of evolution by natural selection?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**20) What gas do plants absorb from the atmosphere?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**21) What is the study of plants called?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**22) What is the capital city of Sri Lanka?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**23) Who won the 2003 Wimbledon women's tennis championship?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**24) What does an orchestra's conductor wave to keep time?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**25) What nationality was Mozart?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**26) Which rock group is Michael Stipe the lead singer of?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**27) Triton is a moon of which planet?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**28) For what process do plants need sunlight, CO2 and water?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**29) Which physicist wrote a book called "A Brief History of Time"?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**30) In which organ of the body is the cerebrum found?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**31) In which country is the world's highest waterfall?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**32) What is South America's highest mountain range?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**33) What is the capital city of Kenya?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**34) Which instrument did the jazz musician Miles Davis play?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**35) Which is the largest stringed instrument in a classical orchestra?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**36) Which artist painted the Mona Lisa?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**37) What is a *killdeer*?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**38) What was the name of Charles Darwin's ship?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**39) In the fairy tale "Hansel & Gretel" what is the witch's house made of?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**40) Who invented the aeroplane?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**41) Who invented the microphone?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**42) Which ocean is the deepest?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**43) Who was the Roman messenger God?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**44) Cochineal is used to dye food red, what is it made from?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**45) How many standard bottles of wine does a rehoam bottle contain?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**46) How many states are there in the US?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**47) Who wrote Animal Farm?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**48) What is the currency of Russia?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**49) Who wrote a famous diary while hiding from the Nazis in Amsterdam?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

**50) In which city is the cathedral of Notre Dame?**

Answer: \_\_\_\_\_

If you do not know the answer please circle one of the following options:

- A) I am CERTAIN I will be able to recognise this answer later
- B) I am quite sure I will be able to recognise this answer
- C) I will have to guess

## **PART B: RECOGNITION SECTION**

**1) In which country did Chess originate?**

- England
- Germany
- India
- Italy

**2) Which system in the human body controls hormones?**

- Circulatory system
- Endocrine system
- Immune system
- Reproductive system

**3) Which US president was shot 5 days after the end of the American civil war?**

- George Washington
- Thomas Jefferson
- Abraham Lincoln
- John Adams

**4) Which team sport has periods of play called 'chukkas'?**

- Baseball
- Hockey
- Polo
- Rugby

**5) Which language has the most native speakers?**

- Bengali
- English
- Mandarin Chinese
- Spanish

**6) What device mixes air and petrol (gas) for the internal combustion engine?**

- Carburettor
- Choke
- Crankshaft
- Cylinder

**7) Which is the largest planet in our solar system?**

- Saturn
- Pluto
- Neptune
- Jupiter

**8) What is the capital city of Norway?**

- Helsinki
- Oslo
- Paris
- Dubrovnik

**9) In which country will the 2008 Olympic Games be held?**

- England
- China

India  
France

**10) How many strings does a violin have?**

4  
5  
6  
8

**11) What do we call a shape with 8 sides?**

Hectagon  
Polygon  
Octagon  
Dodecahedron

**12) Who developed the theory of relativity?**

Francis Galton  
Louis Pasteur  
Isaac Newton  
Albert Einstein

**13) Which chemical element is represented by the symbol N?**

Nitrogen  
Oxygen  
Nickel  
Hydrogen

**14) In which country is Mount Everest?**

Thailand  
Italy  
Nepal  
Brazil

**15) On which continent is the Sahara desert?**

Europe  
Asia  
Africa  
North America

**16) Which pop singer married British movie director Guy Ritchie?**

Britney Spears  
Madonna  
Kylie Minogue  
Christina Aguilera

**17) Who wrote Tess of the D'Urbervilles?**

Charles Dickens  
Robert Louis Stevenson  
Oscar Wilde  
Thomas Hardy

**18) Which rock group did George Harrison belong to?**

The Rolling Stones  
Pink Floyd

The Beatles  
ACDC

**19) Who developed the theory of evolution by natural selection?**

Charles Darwin  
Albert Einstein  
Isaac Newton  
Francis Galton

**20) What gas do plants absorb from the atmosphere?**

Oxygen  
Carbon Dioxide  
Hydrogen  
Helium

**21) What is the study of plants called?**

Astronomy  
Cardiology  
Botany  
Zoology

**22) What is the capital city of Sri Lanka?**

Bangkok  
Delhi  
Colombo  
Beijing

**23) Who won the 2003 Wimbledon women's tennis championship?**

Serena Williams  
Maria Sharapova  
Jennifer Capriati  
Lindsay Davenport

**24) What does an orchestra's conductor wave to keep time?**

Wand  
Baton  
Stick  
Pen

**25) What nationality was Mozart?**

Austrian  
Swiss  
Norwegian  
German

**26) Which rock group is Michael Stipe the lead singer of?**

INXS  
Guns n Roses  
Coldplay  
REM

**27) Triton is a moon of which planet?**

Jupiter  
Saturn

Pluto  
Neptune

**28) For what process do plants need sunlight, CO2 and water?**

Photosynthesis  
Cell adhesion  
Pigmentation  
Lysogeny

**29) Which physicist wrote a book called "A Brief History of Time"?**

Albert Einstein  
Stephen Hawking  
Richard Dawkins  
Steven Pinker

**30) In which organ of the body is the cerebrum found?**

Heart  
Liver  
Brain  
Lung

**31) In which country is the world's highest waterfall?**

Venezuela  
Brazil  
Canada  
Zimbabwe

**32) What is South America's highest mountain range?**

Andes  
Himalayas  
Pennines  
Alps

**33) What is the capital city of Kenya?**

Livingstone  
Kampala  
Nairobi  
Johannesburg

**34) Which instrument did the jazz musician Miles Davis play?**

Saxophone  
Piano  
Trombone  
Trumpet

**35) Which is the largest stringed instrument in a classical orchestra?**

Violin  
Double Bass  
Cello  
Viola

**36) Which artist painted the Mona Lisa?**

Leonardo da Vinci  
Pablo Picasso

Vincent van Gogh  
Henri Matisse

**37) What is a killdeer?**

An American bird  
A hunting jacket  
A rock used as a boat anchor  
A theatrical critic

**38) What was the name of Charles Darwin's ship?**

The Enterprise  
The Beagle  
The Santa Maria  
The Endeavour

**39) In the fairy tale "Hansel & Gretel" what is the witch's house made of?**

Chocolate  
Cake  
Gingerbread  
Sugar

**40) Who invented the aeroplane?**

Orville & Wilbur Wright  
Alfred B Nobel  
Alexander Graham Bell  
Thomas Alva Edison

**41) Who invented the microphone?**

Alexander Graham Bell  
Michael Faraday  
Elisha G Otis  
John Boyd Dunlop

**42) Which ocean is the deepest?**

Atlantic  
Indian  
Pacific  
Arctic

**43) Who was the Roman messenger God?**

Pluto  
Mercury  
Apollo  
Mars

**44) Cochineal is used to dye food red, what is it made from?**

A plant  
A beetle  
A Mineral  
A Fish

**45) How many standard bottles of wine does a reboam bottle contain?**

2  
4

6  
8

**46) How many states are there in the US?**

- a. 49
- b. 50
- c. 51
- d. 48

**47) Who wrote Animal Farm?**

Franz Kafka  
Aldous Huxley  
Charles Dickens  
George Orwell

**48) What is the currency of Russia?**

Ruble  
Peso  
Franc  
Dollar

**49) Who wrote a famous diary while hiding from the Nazis in Amsterdam?**

Helen Keller  
Edith Piaf  
Anne Frank  
Stella McCartney

**50) In which city is the cathedral of Notre Dame?**

Paris  
London  
Rome  
Madrid

**Appendix v: Words used in the “Recollective Experience” task**

<b>Presented words</b>	<b>Kucera-Francis Frequency</b>
Back	967
Court	230
Heart	173
Sago	1
Man	1202
Presage	1
Surface	200
Life	715
Obverse	1
Right	613
Moment	246
Mica	1
Time	1599
Kale	1
Road	197
Well	897
Glanders	1
World	787
Office	255
Fay	1
Job	238
Data	173
Part	500
Clod	1
Three	610
Bathos	1
Earth	150
Good	807
Amide	1
Church	348

<b>Distractors</b>	<b>Kucera-Francis Frequency</b>
Long	755
Board	239
Arbor	1
Cost	229
State	808
Layette	1
House	591
Door	312
Way	909
Halma	1
Field	274
Island	167
Day	686
Finial	1
Market	155
North	206
People	847
Extern	1

Question	257
Sound	204
Capstan	1
Morel	1
Year	660
Wall	160
Small	542
Barium	1
Rand	1
Thought	515
Parry	1
Work	760

## Appendix vi: Source Monitoring Task

This task is about memory. I am going to put some of these objects in pairs, and I am also going to ask you to put some of these objects in pairs. I will tell you which ones to pair, and we will take it in turns. We are going to do this once now with this set of objects, and again later with a different set of objects. I want you to try and remember which objects we pair together, who puts them in pairs (me or you), and whether we put them in pairs in this first session or in the next session. Later on today and I going to give you a memory quiz to see how much you can remember.

### **Set One:**

<b>Condition</b>	<b>Object 1</b>	<b>Object 2</b>
Watch	Bell	String
Perform	Baby	Balloon
Watch	Cup	Key
Perform	Battery	Teabag
Watch	Ball	Ring
Perform	Car	Envelope
Watch	Triangle	Mirror
Perform	Chair	Barrel
Watch	Horse	Bulldog Clip
Perform	Block	Pen
Watch	Tiger	Stapler
Perform	Torch	Scissors

### **Set Two:**

<b>Condition</b>	<b>Object 1</b>	<b>Object 2</b>
Watch	Tape	Duck
Perform	Calculator	Cotton Bud
Watch	Pencil Sharpener	Ribbon
Perform	Hole Punch	Box
Watch	Spoon	Button
Perform	Rubber Band	Shell
Watch	Stamp	Lid
Perform	Coin	Postcard
Watch	Computer Mouse	Puzzle Piece
Perform	Screwdriver	Stickers
Watch	Dinosaur	Matches
Perform	Bear	Paperclip

### **Recognition Test.**

I am going to read out some pairs of objects now, and I want to tell you whether these were the pairs we made earlier or not. I also want you to tell me how confident you are that you are right, as a percentage between 0 and 100, where 100 % is completely sure and 0% is not at all sure.

### **Original Pairs**

<b>Pair</b>	<b>Who paired</b>	<b>Session 1/2?</b>
Cup/Key	Exp	1
Dinosaur/Matches	Exp	2
Rubber Band/Shell	EN	2

Car/Envelope	EN	1
Triangle/Mirror	Exp	1
Tape/Duck	Exp	2
Battery/Tea Bag	EN	1
Ball/Ring	Exp	1
Calculator /Cotton Bud	EN	2
Pencil Sharpener/Ribbon	Exp	2
Bear/Paperclip	EN	2
Baby/Balloon	EN	1
Spoon/Button	Exp	2
Bell/String	Exp	1
Torch/Scissors	EN	1
Coin/Postcard	EN	2

**Distractor pairs**

Computer Mouse/Stamp  
Chair/Pen  
Tiger/Horse  
Stickers/Hole Punch  
Bulldog Clip/Stapler  
Box/Screwdriver  
Block/Barrel  
Puzzle Piece/Lid

## Appendix vii: Ethics Approval



Dr Robyn Langdon  
Macquarie Centre for Cognitive Sciences  
Division of Linguistics and Psychology

4 October 2006

Dear Dr Langdon

### **RENEWAL APPROVED**

**Title of Project:** Belief formation register  
**Reference Number:** HE29APR2005-R04055

Thank you for submitting a progress report for the above study. Approval for the renewal of the application has been granted, effective 1 June 2006.

The following are standard requirements attached to approval of all projects:

1. Approval will be for a period of twelve months. At the end of this period, if the project has been completed, abandoned, discontinued or not commenced for any reason, you are required to submit a Final Report on the project. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. The Final Report is available at <http://www.ro.mq.edu.au/ethics/human/forms>.
2. However, at the end of the 12 month period if the project is still current you should instead submit an application for renewal of the approval if the project has run for less than three (3) years. This form is available at <http://www.ro.mq.edu.au/ethics/human/forms>. If the project has run for more than three (3) years you cannot renew approval for the project. You will need to complete and submit a Final Report (see Point 1 above) and submit a new application for the project. (The three year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).
3. Please remember the Committee must be notified of any alteration to the project.
4. You must notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that might affect continued ethical acceptability of the project.
5. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University (<http://www.ro.mq.edu.au/ethics/human/>).
6. If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide Macquarie University's Grants Officer with a copy of this letter as soon as possible. The Grants Officer will not inform external funding agencies that you have final approval for your project and funds will not be released until the Grants Officer has received a copy of this final approval letter.

Yours sincerely

A handwritten signature in black ink, appearing to read 'Margaret Stout'.

Dr Margaret Stout  
Director of Research Ethics  
Chair, Ethics Review Committee (Human Research)

CRO Title: (61/88)

ETHICS REVIEW COMMITTEE (HUMAN RESEARCH)

Format: (82%)

MACQUARIE UNIVERSITY (U11A)  
SYDNEY, NSW, 2109 AUSTRALIA  
Numbers: Ph: (02) 9850 7884 Fax: (02) 9850 8779 E-mail: [ethic@ugyc.mq.edu.au](mailto:ethic@ugyc.mq.edu.au)  
<http://www.ro.mq.edu.au/ethics/human>