Improving Planning and Prospective Memory in a Virtual Reality Setting: Investigating the use of Periodic Auditory Alerts in conjunction with Goal Management Training on a Complex Virtual Reality Task in Individuals with Acquired Brain Injury

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Chapter 1: Systematic Review

Reviewing the Evidence for Priming in Verbal Implicit Memory Tasks for Individuals with Alcoholic Korsakoff Syndrome

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Neuropsychological Rehabilitation

(See Appendix 1.1 for contributor's notes)

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Abstract

Background: Individuals with Korsakoff Syndrome (KS) experience severe deficits in explicit memory. Nevertheless, additional care needs precipitating re-location to unfamiliar residential environments means that an important focus of cognitive rehabilitation may be the acquisition of new verbal information, such as learning new names and non-verbal information such as route-learning. The literature on amnesia has highlighted the potential of utilising intact implicit memory to aid recall of information through repetition priming. While previous research has revealed priming on non-verbal implicit memory tasks, there is debate regarding what types of verbal priming individuals with KS are capable of. This paper reviewed the evidence base for priming in verbal implicit memory tasks for individuals with KS. ***Method:*** Systematic searches of identified databases were conducted from 1990 to April 2009 in addition to hand-searches of selected articles' reference lists and specified journals. The main aims and findings of the selected articles were reported and methodology rated with respect to fifteen potential methodological threats. ***Results:*** Eleven articles met inclusion criteria and all reported some benefits of priming, with mixed findings regarding types of processing individuals with KS benefit from and types of information they are capable of being primed on. Methodological issues and clinical implications of these findings for cognitive rehabilitation are discussed. ***Conclusions:*** Available evidence suggests that individuals with KS do show priming effects on verbal implicit memory tasks. Tentative conclusions propose that individuals with KS at a certain level of functioning may show level of processing effects and priming for new information. Recommendations are made for utilising errorless learning approaches within a cognitive rehabilitative framework. The limitations of this review are discussed and recommendations made for future intervention studies using follow-up measures.

Key words: priming, verbal implicit memory, Korsakoff Syndrome

Introduction

Korsakoff Syndrome (KS) is characterised by markedly impaired memory with relative preservation of other cognitive functions such as language and visuospatial functioning (Kopelman, 2002). KS occurs as a result of a nutritional thiamine deficiency, and though it can be caused by restricted diet in eating disorders, the commonest cause is seen as a result of chronic alcohol use with poor diet. Many cases of alcoholic Korsakoff Syndrome are diagnosed following an acute Wernicke encephalopathy episode, involving confusion, ataxia, nystagmus and opthalmoplegia (Kopelman, 2002).

Neuroimaging evidence has shown lesions of the mamillary bodies, dorsomedial thalamic nucleus and anterior thalamic nucleus, contributing to the retrograde and anterograde amnesia observed in KS (d'Ydewalle & Van Damme, 2007). It is also believed that the neurotoxic effects of alcohol produce widespread cortical and subcortical shrinkage, contributing to global aspects of intellectual impairment (Jacobson, Acker & Lishman, 1990). There is neuropsychological evidence of specific frontal/ executive test dysfunction (Hirst & Volpe, 1988; Kopelman, 2002) as well as behavioural signs of emotional apathy and disinhibition (Oscar-Berman, Kirkley, Gansler et al., 2004).

Individuals with KS experience an inability to remember new events and information experienced since the onset of their KS (anterograde amnesia), can be disorientated in time and place, and may experience difficulty recollecting events from the more distant past (retrograde amnesia; Weingartner, Eckardt, Grafman et al., 1993). A distinction can be made between this severe impairment of *explicit* episodic memory, and many aspects of *implicit* memory which it is suggested are preserved in KS. Implicit memory refers to the situation where learning can be demonstrated in the absence of conscious recollection of the learning episode. For example, people with KS can show preserved acquisition and retention of perceptuo-motor skills, such as mirror-writing (procedural memory; Cohen & Squire, 1980). If people with an amnesic syndrome, including those with KS, have preserved implicit memory, the question arises as to whether this can be used to facilitate new learning of information relevant to everyday functioning (Phaf, Geurts & Eling, 2000).

One form of implicit memory process is referred to as priming. This refers to the higher likelihood of re-identifying a previously perceived stimulus, even though the previous stimulus may not be explicitly recollected (Graf, Squire & Mandler, 1984; Graf & Schacter, 1985; Markowitsch, 2005, p 107). It is thought that priming effects are obtained by the "prime" stimulus temporarily activating features of the underlying mental representation (e.g. perceptual, lexical or semantic features) and this sensitises its subsequent activation (when the stimulus is repeated) leading to quicker decision reaction times or accuracy rates during the priming task, even in the absence of conscious recollection of prior exposure to the stimulus (Verfaellie, Cermak, Blackford & Weiss, 1990). Studies of priming therefore offer a means of investigating the nature of preserved memory and learning in patients with amnesia.

A wealth of literature has included KS individuals with those experiencing amnesia of other aetiologies (e.g. head injury/ cerebrovascular injury) to investigate types of learning that are preserved/impaired in amnesia, and in order to better understand the structures and processes involved in normal human memory. A number of different types of experimental tasks have been utilised to investigate priming effects. For example, word-stem completion tasks involve participants being presented with an initial list of words, then later given 3-letter stems and asked to complete them with the first word that comes to mind (Weldon, 1991). It has been found that word stems are more likely to be completed with previously presented words (despite the fact that participants have no explicit recall of the initial list of words). Another task used is the lexical decision task, where participants are presented with a list of words, then asked to decide as quickly as possible whether a stimulus briefly presented is a word or non-word (pseudo-word), or in the case of the category membership decision task, participants must decide as quickly as possible whether an item belongs to a specific category (e.g. animal or fruit/vegetable; Beauregard, Chertkow, Gold et al., 1997).

Mixed findings has led to debate regarding what type of learning and memory is preserved in amnesics, and what type of information is capable of being primed (Van Damme & d'Ydewalle, 2008). Studies have shown how neurologically intact individuals benefit from deeper levels of processing known as semantic processing (e.g. being asked to study particular semantic qualities of the word during study phase/ explain meaning of the word) compared to perceptual processing, considered a more shallow level of encoding (e.g. being asked to count the vowels or letters of the word; Cermak, 1980). It has been found that healthy controls will show level-of-processing effects on explicit memory tasks, that is, they will have better recall of words that were processed semantically. However, whether level of processing effects are apparent in implicit memory tasks in the context of anterograde amnesia is a matter of debate. Some authors report that amnesics show impaired semantic processing (Brunfaut & d'Ydewalle, 1996) while others have argued that amnesics show normal level-of-processing effects for semantic encoding and that any differences between amnesic and healthy controls' semantic processing on implicit memory tasks is a result of explicit memory contamination in the control group (Jenkins, Russo & Parkin, 1998).

There is also debate regarding whether priming effects occur with new information or only for pre-existing knowledge. Some authors argue that priming only occurs in the context of the activation of pre-existing representations - stimuli for which the participant already has existing representations arising from previous exposure (referred to as the 'activation account'; Shimamura & Squire, 1984) whereas others argue that new information can be primed – that is, new learning can occur through the formation of new representations in semantic memory (the 'elaboration account'; Van der Linden, Meulemans & Lorrain, 1994). One way this is investigated is to use pseudo-words which have no pre-existing semantic representation, so that any priming effects may be attributed to new learning. Another way is to investigate priming for high- versus low-frequency words (classified according to how often they are used in the English language). An activation account would support advantageous priming for high-frequency words, as they have strong semantic representations; whereas favourable priming for low-frequency words could be taken as evidence that the novelty of these words has made them more distinguishable, supporting an elaboration account (Phaf et al., 2000).

The finding that amnesics are capable of new learning through implicit memory has significant implications for cognitive rehabilitative approaches to working with individuals with KS. The effects of KS can be devastating, often involving re-location to residential units in an unfamiliar area, with new members of staff to meet additional care needs. Thus in the context of severe memory impairment, there is nevertheless often a great deal of new information to learn over and above the usual memory demands of everyday life. Experimental studies have demonstrated KS participants' intact procedural learning ability on non-verbal implicit memory tasks (e.g. Fama, Pfefferbaum & Sullivan, 2006), but it is less clear whether priming in verbal implicit memory tasks can benefit from semantic processing, and if priming is limited to previously acquired knowledge or whether individuals with KS can be taught new information such as staff names, personally relevant information, etc.

Providing some clarity regarding what KS individuals are capable of being primed on and what processing styles produce optimal outcomes may have important implications for how cognitive rehabilitation approaches may be adapted for working with this specific amnesic group. Indeed, if individuals with KS are capable of verbal learning using priming, this has implications for the type of approach utilised. The fact that KS individuals have impaired explicit memory affects their ability to monitor and correct errors made during the initial learning episode, therefore, one would want to minimise the opportunity for errors to be introduced and continue to be primed (which would make them difficult to extinguish). Thus, if priming of verbal information is present in KS, one implication is that an errorless learning approach may be valuable to facilitate verbal learning.

While there is mixed evidence regarding the effectiveness of utilising errorless learning, vanishing cues methods and computer-based cognitive rehabilitation methods with amnesics to learn new skills/ information (e.g. Glisky, Schacter & Tulving, 1986; Glisky & Schacter, 1987; 1988a; 1988b; Robertson, 1990) there is a lack of studies investigating individuals with KS as a specific group. As mentioned, it is often the case that studies of implicit verbal memory abilities have used a wider amnesic group, despite some argument regarding the additional cognitive deficits and frontal lobe pathology potentially distinguishing KS cognitive ability from other amnesics (Squire, 1982).

Therefore, this review has focused specifically on the evidence base for priming in verbal implicit memory tasks for individuals with KS, evaluating the methodological quality and issues arising from these studies, as well as considering the potential clinical implications of these findings for cognitive rehabilitation.

Selection Criteria

Inclusion Criteria:

Studies investigating priming of verbal material in adults with alcoholic Korsakoff Syndrome.

Exclusion Criteria:

Studies of brain damage/ Korsakoff syndrome arising from other aetiologies. Co-morbid conditions such as dementia or severe intellectual disability. Studies published in a language other than English. Single-case studies, reviews and descriptive studies (no data provided). Studies where KS participants were included in groups with amnesic individuals of mixed aetiologies and no separate KS data was available. Studies focusing on non-verbal learning, e.g. visuo-spatial learning or explicit memory tests, e.g. cued recall/ free recall.

Experimental Methodology:

Preliminary searches had revealed a variety of experimental procedures and tasks utilised in studies therefore inclusion criteria for methodologies were kept broad.

Outcome measures:

An objective measure of outcome, e.g. computer-recorded reaction times, exposure threshold durations, or experimenter-recorded responses with clear objective answers.

Search strategy:

Electronic databases searched were: MEDLINE, EMBASE, PsycINFO, CENTRAL, Cochrane Library, CINAHL, British Nursing Index, and all EBM Reviews – DSR, DARE, CCTR.

Search terms used were:

Mesh terms: [Korsakoff Syndrome], [Wernicke Encephalopathy], [alcohol amnestic disorder], [alcohol-induced disorders],

Keywords:

[ARBD], [thiamine deficiency], [Korsakoff$],

combined with the terms:

[cognitive rehabilitation], [rehabilitation], [executive function$], [memory training], [verbal learning], [priming], [recall], [recognition], [vanishing cues], [errorless learning], [perceptual], [semantic], [implicit]

Limits: English language, human

Year: 1990 – April 2009

Reference lists of the selected articles were searched, as well as any studies citing the articles. Hand searches of the following journals were conducted: Neuropsychological Rehabilitation, Alcoholism: clinical and experimental research.

Article Selection:

Stage 1

Using the search strategy outlined above, 253 articles were identified. All titles and abstracts were read by the main author to identify those studies thought to be relevant to the current review, and from these 52 articles were retrieved in their full-text form.

Stage 2

Full-text articles of selected studies were read by the main author, and those that did not meet inclusion criteria were excluded at this stage (41 articles) leaving 11 articles in total. The inclusion/ exclusion criteria were checked by an independent reviewer randomly selecting 3 included and 3 excluded articles. Any disagreements were resolved through discussion. Inter-rater reliability across quality assessment criteria scoring was assessed by independent ratings of the first 4 articles which had been randomly selected for scoring by the main rater. Kappa for the agreement between raters was 0.9, indicating a good level of agreement. Any differences in quality criteria scoring were resolved through discussion and, where needed, further elaboration was provided on the assessment checklist to address any ambiguity.

<u>Analysis</u>

Variability in methodologies and task measures precluded a meta-analysis being conducted. Instead, this review focused on providing a critical analysis of the methodological quality of these studies. All of these studies used quasi-experimental designs and were experimental rather than intervention-focused. Therefore, a methodological quality checklist was developed by the author (see Appendix 1.2), based on a comprehensive list of recognized criteria for evaluating psychological research outlined by Ellis, Ladany, Krengel & Schult (1996). These potential methodological threats incorporate Cook and Campbell's (1979) 33 threats to validity, Wampold, Davis & Good's (1990) 4 threats and Russell, Crimmings & Lent's (1984) 12 methodological threats. Fifteen potential threats were deemed most important to consider when evaluating the methodologies of the studies meeting the inclusion criteria:

Statistical Conclusion Validity

- **Power calculation reported/ effect sizes calculated** – Considering whether studies have calculated the probability of detecting a true effect, as there are often low sample sizes reported in research involving individuals with KS.
- **Violation of assumptions of statistical tests** – e.g. Heterogeneity of variances, using parametric statistics when ceiling/floor effects are observed or a very small sample size is used.
- **Increased possibility of Type I error –** Multiple statistical comparisons with no adjustment of alpha level.

Internal Validity

- **Unreliable procedure implementation** – Evidence of differing protocols within/ between groups.
- **Reliable measures –** Clear rationale as to why specific tasks/ materials are used. These may have been replicated in previous studies demonstrating reliability or piloted by current authors.
- **Instrumentation** – Ceiling/floor effects in task performance may lead to erroneous conclusions of similarities/differences between control groups and individuals with KS.
- **Implementing randomisation whenever possible –** Being quasi-experimental in design increases the risk of error through non-randomisation; however, randomisation through counterbalancing should be incorporated into the procedure whenever possible.
- **Pre-study assessment of KS participants –** Increased possibility of co-morbid head injuries within this population means initial neuropsychological screening

assessment is important to ensure that this is an adequate representative experimental sample.

- **Pre-study assessment of alcoholic controls –** It is important to ensure that this is an adequate control sample as there is an increased risk of head injury within this population, as well as the possibility of damage through neurotoxic effects of alcohol.

Construct validity

- **Inadequate pre-operational explication of constructs –** For example, the study being unclear as to why it is using explicit instructions in the procedure when stated aims are to investigate implicit memory. Linking stated aims of investigation to the existing debate and previous findings.

External Validity

- **Detailed recruitment methods –** Are specific inclusion/exclusion criteria and recruitment methods stated?
- **Is replication possible based on the study's description of methodology**
- **Limitations of study acknowledged** – Are any serious threats to validity, or plausible rival explanations acknowledged?

Further methodological quality criteria were developed by the author, related specifically to this population group:

- **4-week minimum abstinence in alcoholic control group** – To take account of cognitive recovery following abstention from alcohol.
- **Use of participants from previous experiment** – If an article detailed several individual experiments, and described a new participant sample for each, yet continued to include some participants from earlier experiments, they were

marked down. This is due to such small sample sizes increasing the possibility of individual differences affecting results through multiple testing.

Scoring criteria were: Yes/ Adequate/ Not a Threat = 1, Not Stated/ Not enough information to evaluate/ Inadequate/ Definitely a threat = 0. Scores were calculated as percentages to give an overall quality rating. For studies which detailed several experiments including new participant samples, these experiments were rated separately. The quality rating for each article is summarised in Table 1.

[INSERT TABLE 1 HERE]

This review outlines the main aims and findings of these articles, before describing methodological threats, and finally considering what conclusions can be drawn from these findings and implications for cognitive rehabilitation. Participant characteristics, experimental tasks used and the main findings for each study are provided in Table 2. Where possible, magnitude of priming effects were calculated using the following formula outlined by Cermak, Verfaellie, Milberg, Letourneau & Blackford (1991) - (U-P)/(U+P) x 100, where U equals unprimed score and P equals the primed score. Effect size r (ESr) was calculated where sufficient data was available (Rosenthal & DiMatteo, 2001).

[INSERT TABLE 2 HERE]

Results

Beauregard et al. (1997) utilised a brief multiple presentation (BMP) technique to investigate whether priming effects could be seen on a semantic category membership decision task in the absence of explicit recognition. Priming effects were investigated using BMP (experiment 1), implicit encoding instructions with standard visual presentation (experiment 2) and using explicit encoding instructions with standard visual presentation (experiment 3). Individuals with KS and healthy controls were significantly quicker making decisions regarding whether the word denoted a Fruit/Vegetable (block 1) or Animal (block 2) when words were primed in all 3 conditions. The control group were significantly quicker than the KS group making decisions regarding primed and unprimed words in all 3 conditions.

Brunfaut & d'Ydewalle (1996) compared KS and alcoholic (AL) controls' semantic and perceptual processing abilities using priming on three implicit memory tasks (stem completion, word identification and free association) and one explicit task (cued recall). Participants were required to count the number of vowels in the perceptual condition, and explain the word meaning in the semantic condition. There were no group differences and no level-of-processing effect for rate of stem completions. In the word-identification task, perceptually processed words were recognised quicker than unstudied words overall. KS participants revealed no significant priming effects or level-of-processing effects during the Free Association and Cued Recall tasks. While the AL group performed similarly to KS in the perceptual processing condition in these two tasks, they showed significantly larger semantic processing priming effects in both.

Cermak et al. (1991) investigated priming effects for words, pseudo-words and pseudohomonyms in a perceptual identification paradigm. In experiment 2, they used mixed lists of words, pseudohomonyms and pseudo-words to investigate the robustness of priming for pseudohomonyms. Priming effects for words and pseudohomonyms were similar for AL and KS groups; however KS participants demonstrated lower pseudo-word priming effects. In mixed-list conditions; the pseudohomonym priming effect for KS participants reduced in a list with real words, and disappeared in a list with pseudo-words. The KS group did show some pseudo-word priming though this remained below normal.

d'Ydewalle & Van Damme (2007) investigated whether there are differences between KS and healthy controls in involuntary conscious memory (ICM). Participants completed a word-fragment completion task in the following experimental conditions - Direct condition: instructed to use cues as stems to recall the words, but shouldn't guess, Indirect condition: told to say the first word that came to mind, and Opposition condition: the same instructions as Indirect, but to use another word if this word had been encountered previously in the experiment. Furthermore, to investigate any level-of-processing effects, participants were required to generate an associated word for half of the stimuli (Associative – semantic processing condition) while for the other half they had to count the number of enclosed spaces in the word, e.g. letters such as A, D, P (Enclosure – perceptual processing condition). Both groups showed a level-of-processing effect with significantly more priming after semantic versus perceptual processing in Indirect and Direct tests. Within the Opposition condition, KS demonstrated positive priming in both encoding conditions meaning that old items were not inhibited during stem completion. Cueing did not produce more priming in the KS group for the Direct (explicit recall) test, or show more inhibitory priming in the Opposition test (experiment 2), and when allowed to guess, KS individuals showed the same levels of priming in the semantic processing condition as controls, yet were unable to "remember" the items (experiments 3 and 4). All priming effects were significant (for both groups in both processing conditions) in these experiments.

Hamann, Squire & Schacter (1995; Experiment 4) compared KS, amnesics with mixed aetiologies and healthy participants' ability to accurately recognize words across a variety of exposure durations using a perceptual identification task. The 3 groups were equivalent in the baseline condition, primed condition, and in magnitude of priming at each exposure duration.

Jenkins, Russo & Parkin (1998) examined level-of-processing effects by utilising semantic versus perceptual processing on a word-fragment completion task, comparing individuals with KS, closed head-injury (CHI) and healthy controls. There were 3 different processing conditions: 1. to rate pleasantness of the word (semantic condition), 2. counting syllables (syllable judgement) and 3. counting ascending and descending letters (physical condition). While all groups showed a reliable priming effect, and an overall level of processing effect indicating that priming benefited from deeper levels of processing at study, the controls did show larger level of processing effects for the 3 processing conditions.

Komatsu, Mimura, Kato & Kashima (2003) investigated the effects of modality change, that is, the perceptual specificity of implicit memory, by changing the perceptual form of target stimuli. In two experiments, KS and alcoholic controls were presented with a list of Japanese nouns in either Kanji or Hiragana script (these two have distinct orthographies while the meaning of the word remains the same), and had to rate their like/dislike of the word, before undertaking a word-fragment completion test in Hiragana. Recognition tasks were administered in both experiments. The matched-script condition produced more priming in both experiments whereas when the writing script changed between the study and test phases, repetition priming in the word-fragment completion task was significantly attenuated but was still reliable against baseline performance. KS participants demonstrated severely impaired recognition memory in both within-script and cross-script conditions.

Phaf et al. (2000) compared KS and healthy controls' performance for high- versus low-frequency word priming on a word-stem completion task. Both groups performed similarly, showing more priming for low-frequency than high-frequency words. The implicit word frequency effect appeared smaller for KS than controls, however this difference was not significant.

Smith & Oscar-Berman (1990; Experiment 2) compared KS and AL's priming for real words and well-learned word pairs (unitised items) versus novel items (pseudo-words) or unrelated word pairs (non-unitised items) on a lexical decision task. Alcoholic controls showed a significant effect of repetition for words and pseudo-words, while the KS group showed significant priming effects for words but no significant difference between repeated & non-repeated pseudo-words. Whereas there was no significant change in accuracy rates in the second presentation for the AL group, the KS group classified repeated words more accurately than non-repeated words and classified repeated pseudo-words less accurately.

Verfaellie, Cermak, Letourneau & Zuffante (1991) compared KS and alcoholics abilities to make lexical decisions about words and pseudo-words (experiment 1), varying from low- to high-frequency words (experiment 2) repeated at different time lags in a series of experiments. The third experiment explored episodic memory using a recognition measure during the lexical decision task. The KS group showed repetition priming effects for real words presented at long lags similar to alcoholics. Pseudo-word priming was only seen in the AL group and diminished at longer lags. Both groups showed larger priming effects for low- than high-frequency words, though responses to high-frequency words remained faster at first and second presentation. KS participants demonstrated severely impaired explicit memory in the recognition task.

Verfaellie et al. (1990) investigated KS and alcoholic control's implicit verbal memory performance using categorical and associative priming on 3 semantic memory tasks (two perceptual identification and one lexical decision task). Both groups showed intact priming when they were required to identify briefly presented targets preceded by associatively or categorically related primes. Priming effects were found for both groups in high- and medium- associative conditions compared to unrelated words. High- versus Medium-associates did not significantly affect exposure duration. The third experiment revealed that the KS group, similar to controls, responded faster in a related prime-target condition than in a condition in which prime and target were unrelated.

Methodological Quality of Studies

Overall, methodological quality of the studies reviewed was reasonable, ranging from 53.5-100%, the median was 80%.

Statistical Conclusion Validity

Power calculation/ effect sizes

Two studies reported effect sizes/power calculations (Phaf et al., 2000; Smith & Oscar-Berman, 1990) - failing to do so increases the possibility of Type II error. Indeed, Beauregard et al. (1997) report equivalent priming effects in all three experimental conditions of their task with no group differences for magnitude of priming. However, calculation of effect sizes (ES) reveal only small effect sizes for both groups in the BMP and SVP-explicit encoding conditions, with medium effect sizes in the implicit-encoding condition. Four studies did not report sufficient data to allow ESr to be calculated, and no studies provided an a priori power calculation, therefore failing to provide a rationale for their specific sample size and the likelihood of achieving statistical significance.

Violation of parametric assumptions & risk of Type I error

All of the articles used parametric statistics despite the majority of articles having low sample sizes (range 6-26). Three articles scored 0 due to continuing to test when ceiling effects were observed, or failing to report any standard deviations to assess homogeneity of variance. Two articles conducted multiple comparisons, failing to use post-hoc analyses, adjusting for inflated Type I error.

Internal Validity

Standard procedures & reliable measures

Ten studies reported clear procedural instructions and reliable measures.

Ceiling/floor effects & randomisation/ counter-balancing

One study (Cermak et al., 1991; Experiment 2) reported observing ceiling effects in the control group yet continued to statistically analyse the data violating parametric assumptions. Ten articles reported implementing counter-balancing procedures within their experimental design.

Pre-study assessment of the KS and control group

All studies reported at least one pre-experimental measure for KS participants, and four out of the six articles which used alcoholic control groups reported pre-experimental measures. One article (Hamann et al., 1995) provided neuro-imaging results for KS participants, reporting locus of damage.

Construct Validity

Inadequate pre-operational explication of constructs

Brunfaut & d'Ydewalle (1996) and Cermak et al. (1991) were rated 0 for lack of clarification regarding what constructs/ processes they were investigating. For example, Cermak et al. (1991) claimed to be investigating priming on an implicit memory task, yet all participants were given explicit instructions to remember stimuli at the study phase, potentially biasing controls to use intentional recall in test phases. Indeed, the controls showed ceiling performance on this task.

Limitations acknowledged & replication possible

All studies detailed clearly their methodology and references for experimental stimuli utilised, which would enable replication. Two studies (Beauregard et al., 1997; Brunfaut & d'Ydewalle, 1996) failed to acknowledge any plausible rival explanations for their findings or threats to the validity and interpretation of their results.

Experimental group characteristics

4-week abstinence

Three of the six articles were clear in stating that their alcoholic controls had been abstinent for this minimum period (Verfaellie et al., 1990; 1991 clearly stated abstinence periods in experiment 1 of both papers, however, were scored down on subsequent experiments using new participant groups which failed to clearly state abstinence).

External Validity

Inclusion/ exclusion criteria & repeat testing of participants

This was a limitation of most studies, with only three articles reporting adequate information on how their participant sample had been recruited. This limits comparability of results, in that one study may have selected a sample of the most high-functioning KS individuals who had been referred specifically for cognitive rehabilitation approaches (e.g. Phaf et al., 2000), whereas other studies may use convenience samples of individuals who have been in long-stay psychiatric/ residential units (e.g. Brunfaut & d'Ydewalle, 1996). Three articles had included several experiments mixing new and repeating participants, thus increasing possible risk of bias through multiple testing.

Discussion

All of the studies included in this review reported priming effects for KS participants in implicit verbal memory tasks, suggesting that repetition of stimuli facilitates performance on subsequent tasks, without explicit recall of this initial presentation. Mixed findings emerged regarding whether individuals with KS show level-of-processing effects in implicit verbal tasks, as well as whether they are capable of acquiring new information through priming. Therefore, consideration will be given as to possible reasons that studies have found mixed results, before outlining the potential implications of these findings for cognitive rehabilitative approaches for individuals with KS.

Level-of-processing effects in implicit verbal memory tasks

d'Ydewalle & Van Damme (2007) and Jenkins et al. (1998) reported level-of-processing effects for semantic processing in KS participants, while one study reported no additional benefits of semantic encoding (Brunfaut & d'Ydewalle, 1996). Methodological limitations were identified in Brunfaut and d'Ydewalle's study, with low sample sizes and failure to report adequate data to consider whether the study was under-powered. Furthermore, Ramponi, Richardson-Klavehn & Gardiner (2007) have highlighted the potential confounding variable of explicit memory contamination; where participants use a voluntary retrieval strategy, i.e. in the Free Association task where they are instructed to respond with the first item coming to mind, they make deliberate attempts to respond with studied items. This contamination problem is more likely in controls, due to their intact episodic memory. Therefore, an alternative explanation for Brunfaut & d'Ydewalle's (1996) findings of group differences may be that the controls were using an explicit retrieval strategy in the (implicit) Free Association task exaggerating between-group differences in performance. In addition to this, the authors failed to report adequate data to calculate whether any priming effects were seen for the KS group on this task.

To investigate semantic priming effects while reducing the likelihood of explicit memory contamination, Beauregard et al. (1997) utilised a brief multiple presentation (BMP) technique. Priming effects were observed across three experiments manipulating exposure duration to be above/ below the threshold for awareness, leading the authors to conclude that BMP may be an effective paradigm to utilize when investigating implicit memory performance while reducing the risk of explicit memory contamination.

A level-of-processing effect was observed by Jenkins et al. (1998) and though KS semantic priming effects remained lower than controls, the authors suggested that it is likely that explicit memory contamination occurred in the control group. Nevertheless, an alternative argument for the observed level-of-processing effect could be that the perceptual processing condition was overly difficult in comparison to the semantic and syllable tasks.

d'Ydewalle & Van Damme (2007) also found a level-of-processing effect, with significantly more priming after semantic versus perceptual processing. As KS participants showed similar levels of semantic priming as controls when they were allowed to guess, the authors proposed that this reflected intact involuntary unconscious memory (IUM) while they exhibited impaired involuntary conscious memory (ICM) within the Opposition condition (obtaining positive priming in both encoding conditions thus demonstrating suppression failures).

There are possible methodological discrepancies which may provide some explanation for the mixed findings observed in the three studies (excluding Beauregard et al., 1997, as they did not compare semantic and perceptual processing). d'Ydewalle & Van Damme (2007) were the only study to provide detailed recruitment methods, aiming to include individuals who had been carefully screened before referral to the care facilities, whereas Brunfaut & d'Ydewalle (1996) report using KS participants from a psychiatric institution, Jenkins et al. (1998) fail to provide information (the potential significance of differences in recruited populations is discussed later). Furthermore, only d'Ydewalle & Van Damme (2007) report adequate data to allow calculation of effect sizes, where it can be seen that the KS group demonstrated medium-large semantic processing effect sizes across the experiments. Therefore, on the basis of these mixed findings, it can be concluded that the evidence so far, reported in a study with good methodological quality, shows that at least in some experimental paradigms (and in some levels of KS-impairment) individuals with KS will show a beneficial effect of semantic processing over perceptual processing.

Activation versus Elaboration Account

As highlighted earlier, the question of whether priming may be present for new learning (elaboration) or only for tasks involving the activation of pre-existing representations (activation account) is a wider issue in the amnesic literature. However, this review will focus on what the evidence has been for individuals with KS.

Smith & Oscar-Berman (1990) found intact priming for words, with impaired pseudo-word priming in the KS group, supporting an activation account. However, it has been argued that choice of task may determine whether pseudo-word priming is observed. Using a lexical decision task, second presentation of pseudo-words may evoke familiarity without having the conscious recollection to determine whether this feeling of familiarity was attributable to lexical status or to the recent study phase (Smith & Oscar-Berman, 1990). Therefore, longer reaction times may reflect KS participants' conflict regarding sense of familiarity yet having to dismiss it as a non-word, which would suggest some form of preserved learning of novel information. Using a perceptual identification rather than lexical decision task would remove this confounding factor; however, Cermak et al. (1991) did not find significant priming for pseudo-words using a perceptual identification task.

As pseudo-words differ from words in orthography as well as phonology, meaning that either perceptual familiarity or semantic activation could account for any word priming effects obtained; Cermak et al. (1991) included pseudohomonyms, which do not have an existing orthographic representation but share their phonology with real words. Impaired pseudo-word priming, but intact pseudohomonym priming (though less robust than real word priming) suggested that KS participants could access meaningful representations through a phonological route, therefore supporting an activation account. Nevertheless, they conclude that the fact some pseudo-word priming was observed suggests that though KS implicit memory for novel information is definitely impaired, it does exist to some extent. However, methodological limitations in this study are highlighted, with lack of data reported to calculate effect sizes, and participants given explicit encoding instructions to remember the items initially, possibly accounting for the difference in group scores (as controls are using intentional retrieval rather than the KS group showing deficits in implicit pseudo-word priming). Shimamura & Squire (1984) have highlighted how explicit/implicit encoding instructions can influence amnesic participants' performance. Phaf et al. (2000) observed larger priming effects for low-frequency words than high-frequency words in KS and control groups, providing support for an episodic familiarity account rather than semantic activation hypothesis.

Therefore, it can be seen that findings supporting an activation versus elaboration account may depend on the implicit task used. There is the potential confounding variable of familiarity without explicit recall which limits generalisation of results from the experiments using pseudo-words in lexical decision tasks. In addition to this, studies should be clear whether they are providing instructions which are likely to prompt explicit or implicit encoding. The study with the highest methodological quality overall was Phaf et al. (2000), who found a larger priming effect for low-frequency words on word-stem completion tasks, supporting the view that priming is not limited to the activation of pre-existing representations. Furthermore, it should be noted that only Phaf et al. (2000) provided details of recruitment methods, aiming to select individuals with the highest level of functioning. Therefore, tentative conclusions can be drawn, that there is some evidence that depending on type of experimental paradigm and level of impairment, individuals with KS can show priming for new information.

Implications for cognitive rehabilitation

Since the 1970's, studies investigating KS have focused on clarifying theoretical information processing and memory constructs, rather than considering remediation (Allen, Goldstein & Seaton, 1997). While the study of spared learning abilities in amnesia raises interesting theoretical issues regarding the types of processes spared, the practical usage of this information must be considered; how spared learning abilities can be used to address some of the everyday difficulties experienced by individuals with memory problems (Glisky, Schacter & Tulving, 1986).

The finding that individuals with KS are capable of some semantic processing implies that they may benefit from instructions to encode information at a deeper level using a repetition paradigm, therefore, this could be utilised in cases where verbal information such as names or personal orienting information have to be re-learned. However a difficulty with this is that KS individuals may actually be more severely impaired in learning new names compared to other types of semantic information (Pitel, Beaunieux, Guillery-Girard et al., 2009). Pitel et al. (2009) argue that face-name learning may require the differential involvement of episodic memory, as the uniqueness and specificity of proper names means that a word is arbitrarily associated with its visual representation (a face). Therefore, further research is required to consider if, and how exactly, this knowledge of the benefits of semantic processing in laboratory settings can be put to practical use to address KS individuals' everyday problems.

The possibility that KS individuals may be able to acquire new information is a positive finding, as individuals with KS may have to orientate themselves to new surroundings, due to changes in their living circumstances. Therefore, these findings have implications in cognitive rehabilitation for helping individuals with KS acquire simple pieces of ecologically relevant information (termed "domain-specific knowledge" by Glisky, Schacter & Butters, 1994). These approaches could be utilised when using cognitive re-training techniques such as assistive or prosthetic devices (including computers, diaries and lists; Allen et al., 1997). Indeed, Glisky, Schacter & Tulving (1986) report a group of participants with amnesia of other aetiologies who were able to learn new information on a computer. Furthermore, the transfer of learning from laboratory to real world has been demonstrated in the case study of a memory-impaired individual who was able to acquire knowledge which enabled her to return to computer-related employment (Glisky & Schacter, 1987). Nevertheless, Glisky et al. (1986) have described how memory-impaired individuals may experience difficulties self-initiating actions, and may require a highly structured environment in which to operate. They emphasise the "hyperspecific" nature of any knowledge acquired; whereby it is inflexible, rigidly organised and only narrowly accessible, therefore further work is required to consider how this can transfer to practical use in everyday situations (Glisky et al., 1986).

The finding that individuals with KS have intact IUM, that is, awareness without specific recall, means that they are vulnerable to the impact of making errors during learning and highlights the importance of an ‘errorless’ learning strategy (Evans, Wilson, Schuri et al., 2000). Errorless learning involves helping individuals learn new information/skills while they are prevented as far as possible, from making mistakes (Baddeley & Wilson, 1994). It is argued that the benefit of errorless over errorful learning comes from amnesics impaired explicit memory, which does not allow them to discriminate against familiar (but wrong) items retrieved automatically from implicit memory, which can lead to the priming of errors in implicit memory (Kessels & Haan, 2003; Page, Wilson, Shiel et al., 2006).

As KS results in markedly impaired explicit memory, individuals may benefit more from an implicit learning approach utilising repetition priming and errorless learning techniques. Indeed, several studies looking at new learning in KS using explicit memory paradigms have shown poor results for learning and retention (e.g. Komatsu et al., 2000; Pitel et al., 2009). To date, only a very small number of single-case studies have investigated cognitive rehabilitation approaches for KS. Wilson, Baddeley & Evans (1994) found errorless learning to be effective in helping an individual with KS learn to programme an electronic memory aid; while Heinrichs, Levitt, Arthurs et al. (1992) investigated the learning and retention of a daily activity schedule using a letter-fragment cueing method.

Frontal-lobe deficits including attentional and motivational factors should also be taken into account for people with KS. As Phaf et al. (2000) noted their KS group were distracted with low motivation, requiring continual prompting. They propose that KS participants will show poorer performance on tasks where they are required to use their own initiative in storing and recollecting information, and hypothesise that this may account for why KS patients exhibit such impaired explicit memory performance, while appearing to have some remaining elaborative skills. This was supported by Verfaellie et al. (1990) who suggested that when externally driven, search through semantic memory may occur normally for KS, but when search involves self-directed retrieval processes, performance breaks down. Furthermore, Hamann et al. (1995) have highlighted how task parameters may differentially affect KS participants, compared with amnesics with differing aetiologies and healthy controls. Best performance was found when large stimuli were presented, at large visual angles, with a particular type of masking stimulus.

Therefore, cognitive rehabilitation approaches focusing on the learning of verbal information may benefit from utilising an implicit memory repetition paradigm with adequate task parameters, encompassing errorless learning approaches, and ensuring external guidance with prompting is provided. However, it must be emphasised that while these findings support KS individuals' intact verbal priming abilities, research is at an early stage considering how this can be used practically. Further research is required to consider how repetition priming can be utilised to benefit KS individuals in everyday life, and evaluate whether these gains can be maintained when cues are extinguished (which would imply that learning has become explicit – if individuals are able to use intentional retrieval strategies), or whether cueing would have to be continually incorporated into their environment to maintain this effect.

Limitations of studies reviewed

Potential confounding variables have been discussed, such as the task selected to investigate new learning producing bias for certain stimuli. A clear limitation is also the threat of explicit memory contamination when comparing KS and healthy controls/ alcoholics, as investigators need to consider whether any observed group differences in implicit memory performance can be attributed to the neurologically intact group using explicit intentional retrieval strategies which are not available to KS groups. The possibility of procedural instructions biasing the selection of an implicit or explicit encoding/retrieval strategy has been identified, as well as how task parameters utilised may inadvertently affect performance. The impact of subject-variables specific to KS such as lack of effort/ poor motivation have also being identified. Only a small number of studies reported adequate inclusion/ exclusion criteria; therefore, it is possible that the KS sample tested had an influence on the results, e.g. KS participants recruited from impoverished institutional settings are likely to show more impairment than individuals who have been selectively screened as being considered likely to benefit from cognitive rehabilitation. This creates problems in generalising the findings, unless it has been clearly documented at what level of functioning the KS individual must be at to benefit from the experimental manipulation. A final point that must be noted is the need for all studies to provide pre-experimental assessment measures and report abstinence periods when using an alcoholic control group, as it is known that these individuals exhibit global cognitive impairment early in abstinence (Allen et al., 1997). Furthermore, Pitel et al. (2007, 2008) have reported working memory and episodic impairments in individuals with a long period of alcohol use, therefore, one must consider whether similar outcomes on tasks reflect intact KS ability, or impaired alcoholics' performance; pre-experimental neuropsychological measures would aid this investigation.

Limitations of this review

As has been emphasised, this review is specifically focused on investigating implicit verbal priming for individuals with KS, and while this has highlighted some of the issues within the wider amnesic literature, it has not attempted to address findings within the wider field. By only including published studies in this review, there is the potential for publication bias, as it is known that trials with statistically significant results are more likely to be published (Egger, Davey Smith & Altman, 2001). Only studies published in English were included which presents another limitation. Furthermore, this review only included studies which used KS-only groups, and excluded single-n designs; therefore, there is the possibility that other good-quality findings have been excluded.

Final Conclusions

This review considered the evidence base for priming in verbal implicit memory tasks for individuals with KS. Eleven articles were reviewed, with the majority displaying reasonable methodological quality. All of the studies reported some priming effects;

therefore, it does appear that individuals with KS are capable of priming on verbal implicit memory tasks, in a similar way that existing literature supports their priming ability on non-verbal implicit tasks. Nevertheless, mixed findings were reported regarding what types of information KS individuals were capable of showing priming effects for, and what types of processing were most beneficial. Potential confounding variables which may have influenced these mixed findings have been discussed, and weighting has been given to those studies which have exerted clearer control over these sources of bias. Therefore, tentative conclusions can be drawn that some individuals with KS (who may need to be at a certain level of functioning) are able to show semantic processing benefits (level-of-processing effects) on verbal implicit memory tasks. Likewise, select groups of KS participants may show evidence of (some) new learning depending on type of memory task employed and level of external guidance/ support provided.

Implications for future research

As all of the articles reviewed here have utilised experimental designs, outcome research employing single-case and group designs would provide valuable information regarding the efficacy of utilising priming to benefit rehabilitation techniques. In addition to this, it is recommended that future studies include follow-up measures in order to determine whether implicit verbal priming which has been observed to have short-term effects with KS participants can provide longer-term benefits.

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Table 1: Study Quality Ratings

Author	power calculation/ effect sizes reported	violation of parametric assumptions	Risk of Type I error	standard procedure	reliable measures
Beauregard et al. (1997)	0	1	1	1	1
Brunfaut & d'Ydewalle (1996)	0	0	1	1	1
Cermak et al. (1991) exp.1	0	0	0	1	1
Cermak et al. (1991) exp.2	0	0	0	1	1
d'Ydewalle & Van Damme (2007) exp.1	0	1	1	1	1
d'Ydewalle & Van Damme (2007) exp.2	0	1	1	1	1
d'Ydewalle & Van Damme (2007) exp.3	0	1	1	1	1
d'Ydewalle & Van Damme (2007) exp.4	0	1	1	1	1
Hamann et al. (1995)	0	1	1	1	1
Jenkins et al. (1998)	0	1	1	0	0
Komatsu et al. (2003) exp.1	0	1	1	1	1
Komatsu et al. (2003) exp.2	0	1	1	1	1
Phaf et al. (2000)	1	1	1	1	1
Smith & Oscar-Berman (1990)	1	1	0	1	1
Verfaellie et al. (1991) exp.1	0	1	1	1	1
Verfaellie et al. (1991) exp.2	0	1	1	1	1
Verfaellie et al. (1991) exp.3	0	1	1	1	1
Verfaellie et al. (1990) exp.1	0	1	1	1	1
Verfaellie et al. (1990) exp.2	0	1	1	1	1
Verfaellie et al. (1990) exp.3	0	1	1	1	1

Author	**ceiling/floor effects**	**randomisation**	**experimental – pre-study assessment**	**controls – pre-study assessment**	**constructs defined**
Beauregard et al. (1997)	1	1	1	1	1
Brunfaut & d'Ydewalle (1996)	1	1	1	0	0
Cermak et al. (1991) exp.1	1	1	1	1	0
Cermak et al. (1991) exp.2	0	1	1	1	0
d'Ydewalle & Van Damme (2007) exp.1	1	1	1	1	1
d'Ydewalle & Van Damme (2007) exp.2	1	1	1	1	1
d'Ydewalle & Van Damme (2007) exp.3	1	1	1	1	1
d'Ydewalle & Van Damme (2007) exp.4	1	1	1	1	1
Hamann et al. (1995)	1	1	1	1	1
Jenkins et al. (1998)	1	1	1	1	1
Komatsu et al. (2003) exp.1	1	0	1	0	1
Komatsu et al. (2003) exp.2	1	0	1	0	1
Phaf et al. (2000)	1	1	1	1	1
Smith & Oscar-Berman (1990)	1	1	1	1	1
Verfaellie et al. (1991) exp.1	1	1	1	1	1
Verfaellie et al. (1991) exp.2	1	1	1	1	1
Verfaellie et al. (1991) exp.3	1	1	1	1	1
Verfaellie et al. (1990) exp.1	1	1	1	1	1
Verfaellie et al. (1990) exp.2	1	1	1	1	1
Verfaellie et al. (1990) exp.3	1	1	1	1	1

Author	replication possible	limitations acknowledged	alcoholics – 4 week abstinence	detailed recruitment methods	Repeated use of some participants	Overall quality rating (%)
Beauregard et al. (1997)	1	0	1	1	1	86.7
Brunfaut & d'Ydewalle (1996)	1	0	1	0	1	60
Cermak et al. (1991) exp.1	1	1	1	0	1	66.7
Cermak et al. (1991) exp.2	1	1	1	0	0	53.3
d'Ydewalle & Van Damme (2007) exp.1	1	1	1	1	1	93.3
d'Ydewalle & Van Damme (2007) exp.2	1	1	1	1	1	93.3
d'Ydewalle & Van Damme (2007) exp.3	1	1	1	1	1	93.3
d'Ydewalle & Van Damme (2007) exp.4	1	1	1	1	1	93.3
Hamann et al. (1995)	1	1	1	0	1	86.7
Jenkins et al. (1998)	1	1	1	0	1	73.3
Komatsu et al. (2003) exp.1	1	1	0	0	1	66.7
Komatsu et al. (2003) exp.2	1	1	0	0	0	60
Phaf et al. (2000)	1	1	1	1	1	100
Smith & Oscar-Berman (1990)	1	1	1	0	1	86.7
Verfaellie et al. (1991) exp.1	1	1	1	0	1	86.7
Verfaellie et al. (1991) exp.2	1	1	0	0	0	73.3
Verfaellie et al. (1991) exp.3	1	1	0	0	0	73.3
Verfaellie et al. (1990) exp.1	1	1	1	0	1	86.7
Verfaellie et al. (1990) exp.2	1	1	0	0	0	73.3
Verfaellie et al. (1990) exp.3	1	1	0	0	0	73.3

Table 2: Study Characteristics and Main Findings

Article & Quality rating	Participant (gender, age-mean & range or SD)[1]	Pre-assessment measures[2]	Task	Variable	Control	Main Findings[3]
Beauregard et al. (1997) 86.7%	15 KS (M, 73, 63-88), 15 HC (10 M, 5 F, 70, 67-86).	KS: WMS-R, LM1 (4.2), LM2 (1.3), DS-F (8.8), VPA (9.1), VR1 (7.4), VR2 (2.9), BNT (42.5), RCPM (26.3)	category membership decision task	Priming: 1.brief multiple presentation 2.standard visual presentat. (SVP) 3.SVP and explicit instructions.	Elderly HC	* **PE** for KS and HC in all conditions. * BMP **PE** (KS = 6.34%, small **ESr** = 0.13; HC = 3.75%, small **ESr** = 0.24). * Implicit encoding–SVP **PE** (KS = 10%, medium **ESr** – 0.32, HC = 5.22%, medium **ESr** = 0.36). * Explicit encoding–SVP **PE** (KS = 7.67%, small **ESr** = 0.26, HC = 2.96%, small **ESr** = 0.18).
Brunfaut & d'Ydewalle (1996) 60%	8 KS (6 M, 2 F, 50, SD=9, 36-62), 8 AL (8 M, 45, SD=4, 38-51).	KS: RBMT – severe memory deficit range WAIS (93) VIQ (100) PIQ (93) No pre-assessment of AL group.	3 implicit (stem completion, word identification, free association) & 1 explicit (cued recall) task	Priming: Semantic vs. perceptual processing	AL	1. Stem completion: similar **PE** for perceptual (42.9%) & semantic processing (41.2%). 2. Word identification: **PE** for perceptually processed words (p<0.04). 3 & 4. Free Association and Cued Recall: No significant **PE** for KS group. * KS: No difference between semantic & perceptual processing in all 4 tasks. * AL: significantly better than KS in semantic processing conditions for Free Association and Cued Recall Test. * *Lack of data reported to calculate between-group **PE** or **ESr**.*

[1] KS = Korsakoff Syndrome group, WKS = Wernicke-Korsakoff group, AL = alcoholic control group, CHI = closed head injury, HC = healthy control group, SD = standard deviation, M = male, F = female

[2] EM = episodic memory, WM = working memory, EF = executive functions, WMS = Wechsler Memory Scale, WAIS = Wechlser Adult Intelligence Scale, VIQ = Verbal IQ, PIQ = Performance IQ, Att = Attention, GM = General Memory, DM = Delayed Memory, AVLT = Adult Verbal Learning Test, DRS = Dementia Rating Scale, BNT = Boston Naming Test, DS-F = Digit Span Forward; VPA = Verbal Paired Associates; VR = Visual Reproduction; RCPMT = Ravens Coloured Progressive Matrices Test

[3] **PE** = Priming effect, **ESr** = Effect size r

Cermak et al. (1991) Exp.1: 66.7% Exp.2: 53.3%	Exp.1: 6 KS (M, 60), 6 AL (M, 59). Exp.2: 7 KS (M, 4 from experiment 1, 66). 7 AL (M, 55).	Exp.1 KS: WAIS-R VIQ (103), WMS (84), WMS-R Att (104), GM (63), DM (54). AL : WAIS-R VIQ (118), WMS (138). Exp.2 KS: WAIS-R VIQ (104), WMS (84), WMS-R Att (108), GM (67), DM (57) AL: WAIS-R VIQ (110), WMS-R Att (111), GM (102), DM (102).	Perceptual identification tasks	Experiment 1: Priming of words, pseudo-words, Pseudo-homonyms. Experiment 2: Priming of words, pseudowords, pseudo-homonyms in mixed list.	AL	* **PE** for words and pseudohomonyms were similar for KS (19.9% & 20%) and AL (13.4% & 14.3%) participants, but dissimilar for pseudo-words (KS = 6.9%, AL = 22.8%). * AL group were significantly quicker identifying pseudo-words (p<0.001). * Exp.2: KS showed some pseudo-word priming (11.95%) though this remained below AL (33.86%). * *Lack of data reported to calculate **ESr.***
d'Ydewalle & Van Damme (2007) All 4 experiments: 93.3%	Exp.1: 24 KS (23 M, 1 F, 53, 41-63), 26 HC (14 M, 12 F, 54, 36-71). Exp.2: 24 KS (20 M, 4 F, 53, 39-72), 24 HC (19 M, 5 F, 51, 45-58). Exp.3: 15 KS (12 M, 3 F, 50, 39-65), 15 HC (11 M, 4 F, 47, 40-67). Exp.4: 26 KS (21 M, 5 F, 54, 36-63), 26 HC (20 M, 6 F, 51, 40-72).	AVLT - KS all in severe memory deficit range, HC all in no-memory deficit range.	Semantic vs. Perceptual processing on word-stem completion task	Priming on Direct, Indirect and Opposition tests.	HC	* Both groups showed a level-of-processing effect with significantly more priming following semantic processing (Associative - 25.8%, large **ESr** = 0.51) versus perceptual (Enclosure - 9.8%; small **ESr** = 0.19; p<0.01) in Indirect and Direct (Associative - 57.1%, medium **ESr** = 0.38; Enclosure - 40%, medium **ESr** = 0.34; p<0.05) tests. * KS demonstrated positive **PE** in both encoding conditions during the Opposition test (Associative - 29.5%, medium-large **ESr** = 0.46; Enclosure - 24.2%, medium-large **ESr** = 0.46).

Hamann et al. (1995) – Experiment 4 86.7%	6 KS (4 M, 2 F, 64, 50-64), 5 amnesics of other aetiologies (2 M, 3 F, 63, 56-71), 10 HC (3 M, 7 F, 62.8, 52-80).	KS: WAIS-R (98.3), WMS-R Att (91), Verbal (72.8), Visual (73), GM (65.5), DM (57.6), Word recall (27%), Word recognition (83.7%), 24-hr recognition of 50 words (30.5) & 50 faces (31.6), DRS (129.3/144 - lost points on memory section), BNT (54.5/60). Amnesics: WAIS-R (108.2) WMS-R Att (102), Verbal (74.6), Visual (76.2), GM (69.2), DM (54), Word recall (34.6%), Word recognition (83%), 24-hr recognition of 50 words (32) & 50 faces (30.8), DRS (134.6 - points lost on memory section), BNT (56.8). HC: WAIS-R: Information (21), Vocabulary (55.1).	Perceptual Identification Task manipulating exposure duration	Priming	HC & mixed amnesic group	* All 3 groups showed equivalent magnitude of priming at each exposure condition. * *Lack of data reported to calculate between-group priming effects or ESr.*
Jenkins et al. (1998) 73.3%	9 WKS (58, SD = 1.1), 9 CHI (33.77, SD = 12.6), 2 x HC groups (number and age unreported).	WKS: NART (103.3), FSIQ (88.2), GMI (57.4). CHI: NART (103.4), FSIQ (91.4) GMI (73.9).	Implicit memory task (word fragment completion)	Effects of perceptual vs semantic processing on priming effects	HC & CHI	* All groups showed reliable priming effects. HC showed larger LOP **PE** (57.5%, 46.9%, 32% versus KS **PE** (22.81%, 36.23%, 22.81%) for the semantic, syllable judgement and physical conditions, respectively. * *Lack of data reported to calculate between-group priming effects or ESr.*

Komatsu et al. (2003) Exp.1: 66.7% Exp.2: 60%	Exp.1: 8 KS (M, 53.6, 38-63). 8 AL (M, 51.5, 9-16). Exp.2: 8 KS (4 from exp.1, 7 M, 1 F, 58.8, 54-68), 8 AL (7M, 1F, 52.9, 36-71).	KS: WAIS-R VIQ (92.3) PIQ (86.1), WMS-R Att (97.3), WMS-R DM (56.1). Exp.2: KS: VIQ (90.8), PIQ (82.8), WMS-R Att (92.8), DM (59.5). No pre-assessment of AL group.	Word-fragment completion & recognition tests	Cross-script and within-script priming	AL	* Matched-script condition: Larger **PE** for both groups across exp.1 (KS = 48.4%, large **ESr** = 0.76, AL = 36.7%, large **ESr** = 0.5) and exp.2 (KS = 35.9%, large **ESr** = 0.52, AL = 55.5%, large **ESr** = 0.72). * Cross-script condition: Repetition priming was significantly attenuated but still reliable against baseline performance (Exp.1: KS = 25.5%, large **ESr** = 0.5, AL = 18.5%, small-medium **ESr** = 0.27; Exp.2: KS = 33.3%, large **ESr** = 0.51, AL = 25.6%, medium **ESr** = 0.4). * KS participants were severely impaired in the explicit memory task in both conditions.
Phaf et al. (2000) 100%	19 KS (12 M, 7 F), 52.7, SD= 6.9), 19 HC (7 M, 12 F, 56.8, SD= 5.4).	KS: WAIS (98.5), 15-word test: Immediate (2.2), Delayed (1.2). HC: Average IQ (124.2) 15-word test: Immediate (8.1), Delayed (7.4).	Comparing high- and low-frequency word priming on word stem completion task	Priming	HC	* Both groups showed more priming for low-frequency words ($p<0.05$; KS = 66.7%, large **ESr** = 0.57; controls = 83%, large **ESr** = 0.77) than high-frequency words (KS = 55.2%, medium-large **ESr** = 0.47; controls = 58.7%, large **ESr** = 0.56).
Smith & Oscar-Berman (1990) Experiment 2 86.7%	8 KS (M, 63.5, SD= 7.3), 8 AL (M, 56.1, SD=8.1).	KS: IQ (95.6), WMS-R GM (66.6), Att (99.1), DM (54.5). AL: IQ (98.9), WMS-R GM (106.4), Att (98.9), DM (108.3).	Lexical decision task – words & pseudo-words	Priming	AL	* AL: **PE** for words 4.1%; small **ESr** = 0.22, $p<0.003$) and pseudo-words (2.9%; small **ESr** = 0.17, $p<0.02$). No effect of repetition on accuracy for identifying words and pseudo-words. * KS: **PE** for words only (7.8%; large **ESr** = 0.68, $p<0.003$). Repeated words were identified more accurately than non-repeated words (**PE** = 8.54%; large **ESr** = 0.6, $p<0.0001$). Repeated pseudo-words were identified less accurately than non-repeated pseudo-words (**PE** = -8.9, medium-large **ESr** = 0.47; $p<0.005$).

Verfaellie et al. (1991) Exp.1: 86.7% Exp.2: 73.3% Exp.3: 73.3%	Exp.1: 7 KS (M, 63, 56-68), 8 AL (M, 60, 56-66). Exp.2: 7 KS (5 in Exp.1, M, 61, 53-67), 8 AL (2 from Exp.1, 59, 57-60). Exp.3: 8 KS (7 in Exp1&2, 63, 54-69), 12 AL (5 from previous exp, 58, 47-62).	Exp.1 KS: WAIS-R (99), WMS (83), WMS-R: Att (101), GM (66), DM (57). AL: WAIS-R (109), WMS (118). Exp.2 KS: WAIS-R (96), WMS (83), WMS-R Att (103), GM (66), DM (56). AL : WAIS-R: (114), WMS (125). Exp.3 KS: WAIS-R: (109), WMS-R Att (100), GM (65), DM (50). AL: WAIS-R: (109), WMS-R Att (109), GM (106), DM (101).	Lexical decision task & Recognition task (exp.3).	Effects of repetition priming using high- and low frequency words, and pseudo-words, presented at different lags. Exp.3 using continuous recognition task (explicit memory task). .	AL	* Real Words: KS group demonstrated **PE** at long lags (Lag 15; 3 msec, small **ESr** = 0.16) similar to alcoholics (3.43 msec, small-medium **ESr** = 0.26). * Pseudo-word priming: Only seen in AL group and diminished at longer lags. * Frequency: Both groups showed larger **PE** for low- than high-frequency words (KS = 2.03, AL = 2.55, $p<0.05$), though responses to high-frequency words remained faster at first and second presentation ($p<0.05$). * KS participants had severely impaired explicit memory in the recognition task ($p<0.01$).
Verfaellie et al. (1990) Exp.1: 86.7% Exp.2: 73.3% Exp.3 73.3%	Exp.1: 7 KS, (M, 62.1, 56-68), 8 AL, (8 M, 60.4, 55-66). Exp.2: 7 KS (5 from exp 1, M, 63, 53-68), 7 AL, (1 from exp 1, 59, 53-62). Exp.3: 7 KS (6 from previous exp. M, 60.7, 53-67), 7 AL (4 from previous exp. 58.7, 57-60).	Exp.1 KS: WAIS-R VIQ (102.1), WMS (83.1), WMS-R Att (102.4), GM (66.4), DM (57.4). AL: WAIS-R VIQ (110.8), WMS (121.3). Exp.2 KS: WAIS-R VIQ (102.4), WMS-R Att (105.3), GM (65.1), DM (55.8) AL: WAIS-R VIQ (118.6), WMS-R Att (102.4), GM (110.6), DM (109.9) Exp.3 KS: WAIS-R VIQ (101.1), WMS (83.3), WMS-R Att (105.6), GM (63.2), DM (54.4). AL: WAIS-R VIQ (115.1), WMS-R Att (96.8), GM (108.4), DM (108.6).	3 semantic memory tasks: 2 perceptual identification & 1 lexical decision task	1. Associative Priming 2. Categorical Priming 3. Associative priming in lexical decision task	AL	* Both groups showed intact priming identifying briefly presented targets preceded by associatively ($p<0.01$, experiment 1) or categorically ($p<0.01$, experiment 2) related primes. * **PE** of 7.37% (medium **ESr** = 0.38) & 5% (small **ESr** = 0.24) for the KS group and 8.5% (large **ESr** = 0.51) & 6% (medium-large **ESr** = 0.4) for the AL group were found in high- and medium-associative conditions respectively, compared to unrelated words. * High- versus Medium-associates did not significantly affect exposure duration ($p>0.10$). * KS performed similarly to controls, responding faster in a related prime-target condition (Mean = 1002 msec) than in a condition in which prime and target were unrelated (Mean = 1068; $p<0.01$).

Chapter 2: Major Research Project

Improving Planning and Prospective Memory in a Virtual Reality Setting: Investigating the use of Periodic Auditory Alerts in conjunction with Goal Management Training on a Complex Virtual Reality Task in Individuals with Acquired Brain Injury

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Abstract

Introduction: Deficits in planning and prospective memory are common after brain injury and contribute to difficulties participating in everyday activities. Recent research has suggested that using non-contingent auditory alerts may facilitate a 'goal-review' process and improve performance on tasks that make demands on executive functions. This study investigated whether combining alerts with a brief goal management training (GMT) programme would improve performance on a complex virtual reality task.

Method: Twenty individuals with evidence of executive impairment completed two versions of the Removals Task, one trial with auditory alerts following a GMT session, and the other trial in standard, non-alerted conditions. Nineteen healthy controls were recruited to complete the task with no alerts or GMT.

Results: The brain-injury group were significantly poorer than the controls on some measures of the task in non-alerted conditions. GMT and auditory alerts did not improve performance (though a sub-group analyses revealed improvement for 6 participants on one task measure).

Discussion: Ceiling effects, brevity of the GMT procedure and paradoxical effects of the alerts on the measures are discussed as some possible reasons for failure to find significant differences. Sensitivity of the Removals Task to detect executive impairment and its efficacy as a potential cognitive rehabilitative assessment tool is investigated in light of differing findings between studies.

Conclusion: The Removals Task revealed differences in performance between individuals with executive dysfunction and healthy controls on some measures. While a sub-group of participants did show improvement in the alerted condition for one measure, GMT and auditory alerts failed to improve performance in the brain-injury group on the majority of task measures. Limitations of the current study are acknowledged and recommendations for future research are given.

Key Words: Prospective memory, Executive dysfunction, Goal Management Training, Rehabilitation, Removals Task

Introduction

Executive functioning is the term used to describe a range of higher-level cognitive processes necessary for successful planning, reasoning, and the control of attention. McDonald and colleagues (2002) report executive dysfunction as a common and disabling aspect of cognitive impairment following acquired brain injury. One function that is vulnerable to the effects of executive dysfunction is prospective memory (PM; realising delayed intentions), as PM is a multidimensional process which makes demands on memory, attention and executive systems (Fish, Evans, Nimmo et al., 2007). Indeed, Hitch and Ferguson have described 3 different stages in prospective remembering – forming a future intention, remembering the intention during an intervening period, and performing the intention at the right moment (1991, cited in Bisiacchi, 1996). As individuals who have experienced damage to the frontal lobes often have difficulty initiating or organizing new goal-directed behaviour, this can lead to PM failures (Glisky, 1996). Duncan, Parr, Woolgar et al. (2008) termed this mismatch between knowledge of what the individual had planned to do and their actual behaviour as goal neglect.

In recent years, a number of studies have suggested that external alerting may be an effective prospective memory rehabilitation technique. Evans, Emslie & Wilson (1998) used an automated paging system (NeuroPage) for an individual with relatively preserved memory functioning who showed a discrepancy between stated intention and the ability to act on these intentions. The intervention was effective in facilitating intended action, the pager alerts apparently acting as an "external executive system", compensating for an impaired frontal-lobe supervisory attentional system.

Subsequently, Manly and colleagues (2002) found a significant improvement in the performance of a group of brain-injured participants completing a multi-element task (the Hotel Task) when participants were provided with non-contingent auditory alerts (random 'beeps'). Burgess, Alderman, Forbes et al. (2006) have argued that the Hotel Task has greater ecological validity than traditional tests such as the Wisconsin Card Sorting Test (WCST), and several studies have reported findings where classical "frontal" tests have failed to distinguish individuals with executive dysfunction from healthy controls, yet these individuals may exhibit severe functional impairment in daily life (e.g. Eslinger & Damasio, 1985; Shallice & Burgess, 1991).

Nevertheless, it is important that the usefulness of auditory alerts is examined in situations that reflect more closely the demands of everyday activities. To this end, Fish and colleagues (2007) found that alerts (delivered via Short Message Service texts) improved the ability of brain-injured participants to remember to make telephone calls at specified times of the day over a two-week period. In addition to text-alerts, participants in Fish et al.'s (2007) study also received goal management training (GMT), a cognitive training programme that aims to improve goal-directed behaviour by instructing individuals to review intended goals and current actions (Levine, Robertson, Clare et al., 2000).

Another approach to testing interventions in ecologically relevant situations, whilst retaining experimental control, is to use virtual reality environments (Morris, Kotitsa, Bramham et al., 2002a; Cobb & Sharkey, 2007). Morris, Kotitsa, Brooks et al. (2002b) developed the virtual 'Removals Task', a novel procedure designed to mimic a complex real-world situation, which assesses strategy formation, rule-breaking and prospective memory. Sweeney, Kersel, Morris & Evans (in press) tested whether auditory alerts would improve performance on this task, but found no effect of alerting in a group of people with executive dysfunction. They hypothesised that, on more complex (ecologically realistic) tasks, a more extensive goal management training, similar to that used by Fish et al. (2007), may be needed in order for people with brain injury to benefit from the use of auditory cueing. The aim of the present study was therefore to investigate whether an intervention combining GMT with periodic alerts would improve the performance of people with acquired brain injury in a complex, virtual-reality task that makes demands on planning and prospective memory.

Aims

1. To compare the performance of individuals with executive dysfunction arising from brain injury with that of healthy controls on the Removals Task.

2. To examine the impact of a combination of Goal Management Training and auditory cues on the performance of individuals with executive dysfunction completing the Removals Task.

Hypotheses

1. It was hypothesised that individuals with executive dysfunction completing the task without GMT/auditory alerts would be impaired compared to healthy controls.
2. The brain-injured group were expected to show improvement in the GMT/auditory cues condition compared to when completing the task in the non-alerted condition.

Method

Sample Size Considerations

This study was powered with regard to the analysis relating to the impact of auditory alerts as this was the primary aim of the study and also considered likely to show a smaller effect size than the simple comparison of brain injured participants and healthy controls on the Removals Task. In terms of Cohen's (1988) criteria, Manly et al. (2002) showed a large effect size (ESd calculated to be 1.02) using auditory alerts on the Hotel Task, a task considered to have similar cognitive demands to the Removals Task (though completed in a shorter time period). Sweeney et al.'s study (in press) found a small-medium effect size (ESd calculated to be 0.25) using alerts during the Removals Task. However, Fish et al. (2007) reported a medium-to-large effect size (ES reported as F^2 =

0.269) using a different prospective memory task when combining auditory cueing and GMT, and this effect prevailed over a two-week period. It was therefore anticipated that by combining GMT and auditory alerts, there would be a larger effect size on the Removals Task than that seen in the Sweeney et al. (in press) study. It was subsequently decided to estimate the sample size required on the basis of an effect size of d = 0.6.

Using a one-tailed matched pairs t-test on the statistical programme G*Power (Faul, Erdfelder, Lang & Buchner, 2007) to compare executive dysfunction group means on the Removals Task with GMT and alerts, versus without GMT or alerts, based on an estimated medium-large effect size (0.6), with alpha error at 0.05 and power at 0.8, it was predicted that 19 participants would be required.

<u>Recruitment</u>

Participants were recruited from Headway organisations in Glasgow and Lanarkshire, as well as two community based rehabilitation centres in Glasgow. Relatives and friends of individuals with acquired brain injury were invited to participate in the control group.

<u>Ethical Approval</u>

Ethical approval was granted by the NHS Greater Glasgow Primary Care Division Local Research Ethics Committee (confirmation letter included in Appendix 2.11).

<u>Participants</u>

Experimental Group

Inclusion criteria: 18-65 year olds with evidence of executive impairment caused by acquired brain injury. Initial recruitment was on the basis of the clinician's judgement with further testing for evidence of executive dysfunction then being conducted. Signed informed consent was obtained before testing, and only those considered to have capacity to consent were approached.

Exclusion criteria: Individuals with learning disability and those with executive dysfunction as a result of neurodegenerative conditions such as dementia. A history of aggression, severe perceptual problems, severe dysphasia (which may affect ability to understand test instructions) and severe mental illness (e.g. psychosis), which in the judgement of the clinical team and/ or experimenter would prevent effective participation in the study.

Using these criteria, twenty participants were recruited to the brain-injured group. These included 4 females and 16 males. Mean age was 46.3 years (SD = 11.9), and head injuries had been sustained at least 1 year prior to the present study (mean = 8.6 years post-injury, SD = 8.4, range = 1-28 years). The Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) was used as a pre-morbid estimate of IQ (mean = 101.1, SD = 10.4).

Control group

Nineteen participants were recruited to the control group. They consisted of 12 females and 7 males. Mean age was 43.3 years (SD = 12.7) and mean estimated full scale IQ (based on the WTAR) was 102.3 (SD = 8.9). They had no previous history of neurological illness or head injury resulting in loss of consciousness.

Both groups did not differ significantly in age ($t(37) = -0.743$, $p = 0.46$, two-tailed) or IQ ($t(35) = 0.362$, $p = 0.72$) but did differ in gender (two-tailed Fisher exact $p = 0.01$).

Measures

Pre-experimental measures

To examine the level of executive impairment, all brain-injured participants completed the Dysexecutive (DEX) questionnaire and Modified Six Elements test from the Behavioural Assessment of Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess et al., 1996a). The Modified Six Elements Test makes demands on a person's ability to plan, organise and monitor behaviour, and has a maximum profile score of 4. The DEX questionnaire covers a wide range of problems commonly associated with the Dysexecutive Syndrome, and can be completed by the participant and a relative/carer (Wilson et al., 1996a).

The Prospective and Retrospective Memory Questionnaire (PRMQ; Crawford et al., 2003, 2006) investigates how memory failures impact on individuals' everyday lives. A separate score for prospective memory failures can also be calculated from this questionnaire. The PRMQ can be completed by the individual, and also a proxy version by their carer/relative.

The Logical Memory (LM) subtest from the Wechsler Memory Scale – 3rd Edition (WMS-III; Wechsler, 1998) and Rey Complex Figure Test (RCFT; Meyers & Meyers, 1995) were used as measures of immediate and delayed verbal and visual recall, respectively. The brain-injury group characteristics and pre-experimental measures are shown in Table 1.

[INSERT TABLE 1 HERE]

Experimental measures and Scoring

In the virtual reality Removals Task (Morris et al., 2002b), the "furniture storage unit" has four main rooms and a hallway (an overhead view of the furniture storage unit is shown in figure 1). The participant was told that they are a removal person instructed to collect furniture and items for owners moving to a new house. They were required to navigate through the storage unit, entering various rooms with different items of furniture in each (images of the internal hall and one of the rooms, as seen by participants, are given in Appendix 2.1) and collect items of furniture according to a sequence relating to the room type in which the furniture would normally be located (e.g. kitchen, bedroom etc.). A **rule break** score was calculated according to whether participants follow the specified room order for collecting furniture and a **strategy** score was calculated for each participant looking at the efficiency of their strategy for collecting furniture (details of how these were scored are given in Appendix 2.2).

[INSERT FIGURE 1 HERE]

Participants could also show 'intrusions' while collecting the furniture:

Intrusion I – where the participant collects furniture for another room while they are collecting for a different room (e.g. removing the bunk-beds while collecting for the kitchen).

Intrusion II – when participants have finished collecting for all the rooms (categories) and realise that they still have furniture remaining which should have been removed for previously completed rooms, therefore would collect it at the end.

There were a number of tests of prospective memory embedded in the Removals Task:

Activity-related:

1. Participants were required to close the front door when they first entered the furniture storage unit (giving the *initial front door close* measure) scoring 1 if they remember to do this within the first 2 minutes of entering, or 0 if they remember out-with this time (the experimenter prompted them to close the door if this time had elapsed).

2. Ability of the participant to remember to close the door of room 2 (version 1) and room 3 (version 2) each time they leave the room. Participants were prompted to close the room door if two minutes had lapsed and this was noted. The number of times the appropriate door was closed was divided by the total number of visits to that room to give this measure.

Time-based Prospective Memory: Participants were instructed to check the front door at 5-minute intervals as they were expecting a removals van to arrive and the door bell was not working. The exact time participants were due to check the door was visible throughout the task at the top of the computer screen (however, a clock showing the actual time was 'frozen' so that participants had to ask the experimenter when they wanted to check the current time). Participants were prompted if they did not go to the front door within two minutes of the time shown. To score this, the exact time the participant checked the front door was compared against the displayed time. Arriving at the door early would get a 'plus' sign, while arriving late would obtain a 'minus' sign.
An unsigned time deviation measure was calculated by taking this difference between time checked and stated time to check, irrespective of 'plus' or 'minus' sign, and dividing this total unsigned time by number of visits to the front door.

Event-related Prospective Memory: This measure relates to the participant's ability to remember to label the relevant fragile items on each version of the Removals Task, with a maximum score of 4. They were also required to leave these items behind (giving an additional point for each item left behind). Therefore, the maximum score on this measure was 8 points.

<u>Design</u>

A quasi-experimental design was used with two testing conditions: completing the Removals Task –

1. With no GMT/alerts.
2. With GMT/alerts.

The control group only completed the no GMT/alerts condition, while the experimental group completed both conditions. Testing conditions and both versions of the Removals Task (used to minimise practice effects) were counterbalanced using sealed opaque envelopes.

Research Procedures

The Removals Task

The Removals Task was delivered via laptop computer. Before learning the instructions for the task, all participants underwent navigation training using "arrow button practise instructions" (Appendix 2.3) and "navigation instructions" (Appendix 2.4). A procedural flowchart is given below (fig. 2).

[INSERT FIGURE 2 HERE]

There were a number of instructions participants had to follow in the Removals Task (see Appendix 2.5 for task instructions):

1. Furniture must be collected in a specific room order.
2. Fragile items must be labelled.
3. Certain room doors must be closed when exiting the room.
4. The front door must be visited at 5-minute intervals.

Rule 1 was used to elicit rule breaking and strategy formation, while rules 2-4 were designed to investigate event-, activity- and time-based prospective memory (Kotitsa et al., 2002). Task instructions were encoded using an errorless learning procedure as there is evidence from the memory rehabilitation literature that it is beneficial to reduce opportunities for errors to be introduced into initial task learning (Wilson, Baddeley, Evans & Shiel, 1994; Wilson & Evans, 1996b). To do this, participants were shown rule 1 at the same time the experimenter read it aloud. This was then concealed and the participant was asked to repeat the rule. They were instructed not to guess, if they did not know the answer they were required to say and the experimenter would repeat it. Following correct recall of rule 1, the same procedure was repeated with rules 2-4. Where individuals showed repeated difficulty recalling the rule when it was concealed, a vanishing cues approach (Glisky & Schacter, 1987) was utilised to gradually remove more of the rule until the participant could recall the entire rule without help. Once the instructions could be recalled three times consecutively without error they began the Removals Task. A summary of the task instructions (Appendix 2.6) and map of the bungalow (figure 1) were placed next to the computer, to ensure that as far as possible, errors/omissions were due to errors in the task's executive demands, rather than its mnemonic demands.

Goal Management Training

GMT was administered using the GMT manual adapted from the Fish et al. (2007) study, who had used an abbreviated version of Robertson, Levine & Manly's GMT Handbook (personal communication; Fish et al., 2007).

Training involved explaining the nature of PM, and the large variety of ways that tasks involving PM can go wrong. Explanations of absentmindedness or running on "autopilot" were given as common routes to failure. A "mental blackboard" metaphor was used to explain how being busy or distracted meant that information contained on this may be temporarily lost, but taking a moment to consider current goals and plans (checking the "mental blackboard"), may allow one to retrieve this information. Examples and exercises were used throughout to explain concepts. Active participation was encouraged, relating material to participants' own experiences and information was summarised throughout the session. As noted by Fish et al. (2007), exact content varied slightly between individuals due to the interactive nature of training, basing it on participant's own experiences. Participants were taught to review their own performance, using the mnemonic STOP – Stop, Think, Organise and Plan. During these reviews, participants were instructed to ask themselves the following sorts of questions – what am

I doing? Do I need to be concentrating? What else have I got to do and when? Do any plans or arrangements need to be made, or can I carry on just as before? What are my goals? Am I achieving these goals? Throughout the training session, the strategy was discussed with reference to the variety of goals that people maintain on a day-to-day basis. When they moved on to learning the instructions of the Removals Task, reference was made to getting these instructions "on the mental blackboard". Participants were given a GMT training booklet to keep at the end of the second trial.

Auditory alerts

Tones were delivered using a portable CD player. As in Sweeney et al.'s study (in press) the tones were formed from a complex wave at approximately 1975 HZ. The tones were of 80 ms duration and played at approximately 50db. The first six tones were presented at 2'14", 5'11", 8'18", 9'59", 11'25" and 13'44" and this sequence was repeated to fill the 60 minute duration of the CD. Participants were informed "during the task you are going to hear random beeps. Now that you have received goal management training you may find it helpful to think back to this and ask yourself the kind of questions we have been practising" – these instructions were aimed at encouraging the participant to review their performance while still being general enough that the participant had to self-initiate this review. In the standard, non-alerted condition, no reference was made to GMT or auditory alerts.

The control group completed the Task once, with no GMT/alerts, as Manly et al. (2002) have described piloting suggesting that control performance would be too close to ceiling to allow useful investigation of the experimental condition. The experimental group were re-tested after 1 week. Testing for the brain injury group lasted no more than 3 hours in total, while the control group testing lasted 90 minutes.

Results

Pre-experimental measures

All brain-injured participants completed the Modified Six Elements task and DEX questionnaire. Mean profile score was 3.2 (SD = 0.95, range = 1-4). Half of participants achieved a perfect score on the limited profile score range. Mean score on the DEX self-rating questionnaire was 29.9 (SD = 16.2, range = 1-66). Fifteen relatives/ carers completed the DEX independent rater questionnaire, where the mean score was 32.4 (SD = 20.4, range = 4-64).

Seventeen participants completed the PRMQ. The overall mean score was 50.9 (SD = 11.2, range = 29-76) and the mean Prospective score was 26.1 (SD = 6.4, range = 13-41). Seventeen relatives/ carers completed the proxy version of the PRMQ (overall mean score = 46.9, SD = 16.1, range = 26-73; mean Prospective score = 24.6, SD = 8.26, range = 12-38). Both the self-rated and independent-rated scores for the DEX and PRMQ questionnaires were above the means reported for healthy control groups, suggesting executive and prospective memory difficulties in this group.

All brain-injured participants completed the LM subtest, where the mean percentile for verbal immediate recall was 38.6 (SD = 18.3; range = 16-74) and verbal delayed recall was 45.8 (SD = 17.5; range = 5-79). The mean percentile for recognition was 83.7 (SD = 11.5; range = 66.7-100). For the eighteen participants who completed the RCFT, performance varied in the immediate recall of the figure, with age-corrected scores between the 1st and 98th percentile (mean = 36.2, SD = 38.8) and between the 1st and 99th percentile (mean = 27.3, SD = 34.3) on the delayed recall trial.

Experimental measures

Parametric statistics were utilised for measures with interval scores that were normally distributed, while non-parametric statistics were used for ordinal data. Therefore, independent samples t-tests and Mann-Whitney Unrelated tests were used to calculate between-group differences while repeated measures t-tests and Wilcoxon Signed Ranks tests were used to compare within-group differences. Descriptive statistics, *t*, *z* or *U* values, significance levels (two-tailed) and effect sizes are given in Tables 2, 4, 5 and 6.

Removals Task performance in the standard, non-alerted condition

Overall, the control group were significantly quicker than the brain-injury group completing the task in the standard, non-alerted condition, as well as compared to the brain injury group's first trial (irrespective of experimental condition; $t(37) = 3.069$, $p = 0.004$, two-tailed). The control group visited significantly less rooms during the task and were significantly more accurate than the experimental group on the time-based PM task – unsigned time deviation.

[INSERT TABLE 2 HERE]

There were no significant differences between the brain injured group and the control group for rule break scores, strategy scores, remembering to close room door 2 (version 1) or door 3 (version 2) or remembering to label fragile items. Comparable performance was found on number of intrusions I made though individuals with executive dysfunction made significantly more type II intrusions than the control group. Both groups performed similarly in their ability to remember to close the front door when initially beginning the Removals Task.

Correlational analyses were conducted, investigating whether there was any relationship between strategy scores, time-based PM, intrusions II and number of rooms visited in the Removals Task, standard non-alerted condition, and the DEX questionnaire (self-rated), Modified Six Elements test and the PRMQ (prospective memory section). None of the correlations reached the level of statistical significance.

[INSERT TABLE 3 HERE]

Brain-injury group: Practice Effects

Practice effects were investigated by comparing participants in the brain-injury group's performance at 1st and 2nd test administration (regardless of which experimental condition had been completed first). Participants in the brain-injury group were significantly quicker on the second trial. Furthermore, when completion time on the second trial was compared with the control group, the difference in completion time between groups was no longer significant ($t(37) = 1.71$, $p = 0.095$, two-tailed, ESr = 0.27).

[INSERT TABLE 4 HERE]

There were no significant differences in strategy scores, rule break scores or number of rooms visited in the first trial compared with the second trial. Likewise, there were no significant practice effects for remembering to label items as fragile or differences in time accuracy for checking the front door.

Brain-injury group: GMT/AA versus standard, non-alerted condition

No significant differences in performance were found for the brain-injury group on the Removals Task comparing the GMT/AA condition versus the standard, non-alerted condition. However, as ceiling effects were observed on several measures in the non-alerted condition, including the Intrusions II measure where 14 participants achieved perfect scores, a separate Wilcoxon analyses was conducted for the 6 participants who had shown errors. This revealed a significant difference between non-alerted and alerted conditions ($z = -2.06$, $p = 0.039$, ESr = 0.7) suggesting that GMT/alerts helped to improve performance in the sub-group of individuals who had made errors.

[INSERT TABLE 5 HERE]

Comparison of 10 participants who completed no GMT/AA condition in first trial

Due to the nature of the counterbalancing design, half of the brain-injury group received goal management training in the first trial, therefore it is possible that some benefits of this training may have carried over into the "no GMT/AA" condition (labelled as such because no further training or reference was made to the previous training episode) possibly obscuring any differences in performance. Therefore, in order to examine whether any differences could be observed, data for the ten participants who completed the Removals Task with no GMT/alerts in the first condition was analysed. No significant differences in performance on any of the measures were found between experimental conditions.

[INSERT TABLE 6 HERE]

Comparing current findings and Sweeney et al. (in press)

While the current results partially replicate Sweeney et al.'s findings, with healthy controls being quicker completing the Removals Task overall and brain-injured participants demonstrating significantly poorer time-based prospective memory (remembering to check the front door at the correct time) in standard non-alerted conditions, the previous study found significant differences between groups on strategy and rule break scores, contrary to the current study. Therefore, in order to investigate these differences, data from the two studies were compared for rule break scores, strategy scores and measures of executive dysfunction.

There were no significant differences between the current brain-injured group and Sweeney et al.'s (in press) experimental group in age ($t(35) = -0.838$, $p = 0.408$, two-tailed, ESr = 0.15), gender (two-tailed Fisher exact $p = 1$) or WTAR scores ($t(33) = -0.728$, p = 0.472, two-tailed, ESr = 0.12). Furthermore, they did not differ significantly on measures of executive impairment: 6 elements ($t(35) = -1.269$, $p = 0.213$, two-tailed, ESr = 0.2), or independently rated DEX questionnaire ($t(26) = 0.561$, $p = 0.580$, two-tailed, ESr = 0.1). However, the groups did differ significantly on scores for the DEX self-rated questionnaire ($t(35) = 2.797$, $p = 0.008$, two-tailed, ESr = 0.42) with Sweeney et al.'s group rating themselves as more impaired (mean = 44.8, SD = 16) than the current group (29.9, SD = 16.2).

The current participants and Sweeney et al.'s group did not differ significantly on self-rated PRMQ ($t(32) = 1.313$, $p = 0.199$, two-tailed, ESr = 0.22) or proxy rated PRMQ ($t(27) = 0.536$, $p = 0.597$, two-tailed, ESr = 0.1). Self-rated prospective memory scores ($t(32) = 1.357$, $p = 0.184$, two-tailed, ESr = 0.23), and proxy-rated prospective memory scores ($t(27) = 0.708$, $p = 0.485$, two-tailed, ESr = 0.13) did not differ either.

Sweeney et al.'s experimental group were significantly more impaired on the rule break score compared to the current brain-injured group ($U = 93$, $p = 0.005$, two-tailed, ESr = 0.49). The current brain-injured group also had significantly higher strategy scores than Sweeney et al.'s group ($U = 106$, $p = 0.048$, two-tailed, ESr = 0.34).

Discussion

Several findings have emerged from this study. The Removals Task was able to distinguish between healthy controls and individuals with executive dysfunction on several measures (completion time, number of rooms visited, number of type II intrusions made and time-based prospective memory – checking the front door). Furthermore, the results revealed that the 6 participants who had committed Intrusion II errors demonstrated significant improvement in the GMT/alerts condition, that is, less furniture was neglected during the task and had to be collected at the end. Therefore, it appears that GMT/alerts were beneficial in reducing goal neglect on this measure. Though one must remain cautious in interpreting this result due to the small sample size, these results cannot be explained by simple order effects as only two of the participants had completed the no GMT/alerts condition on the first trial. Nevertheless, auditory alerts and goal management training did not lead to improvement on any other measures of the Removals Task.

There would appear to be several reasons why the GMT/alerting intervention did not improve performance on the majority of measures used in the Removals Task. Firstly, as the brain-injury group did not differ from controls on activity-based PM measures – closing room doors, event-based PM – labelling fragile items, rule break or strategy scores, it can be argued that alerts and GMT were not able to improve on what appeared to be normal performance. Furthermore, ceiling effects were observed on several measures, with 17 participants obtaining perfect rule break scores and 13 achieving maximum scores within the activity-based PM (closing room doors) in the standard non-alerted condition, leaving little room for improvement among participants in the alerted condition. As already mentioned, the majority of participants demonstrated perfect scores in the Intrusions II measure though separate analyses revealed significant improvements in the alerted conditions for the 6 showing errors.

Based on previous research, one would have expected time-based prospective memory performance to be more amenable to the effects of periodic alerts (e.g. Evans et al., 1998; Fish et al., 2007), something which was not found in this study. Observing participants' behaviour completing the Removals Task has led to possible explanations of why some individuals in the brain-injury group were actually slightly more accurate checking the door (the time-based prospective memory task) in the non-alerted condition. It was apparent that some participants were using the alerts as a prompt to check the front door immediately (despite being reminded that this was not the function of the alerts). Another possible reason why alerts did not improve performance on this measure is that some individuals were observed to incorporate front door-checking into their search strategy; therefore they would check the front door after leaving room 4, regardless of time stated to check the door.

It was hypothesised that a possible reason for inability to detect differences between the alerted and non-alerted conditions could be that those participants who had received GMT in the first condition may have shown carry-over benefits in the 2nd (non-alerted) trial, therefore, data for the ten participants who had completed the no GMT or alerts condition first, and GMT/alerts condition second, was analysed separately. However, no significant differences were found between performances on these trials.

One must also consider the impact of GMT on this task. It may be that the brevity of the goal management training programme utilised in the current study precluded individuals benefiting from alerts on this task. Indeed, in a randomised group trial, GMT demonstrated benefits over motor skills training for improving goal-directed behaviour in individuals with executive dysfunction, though in this study they received a one-hour GMT session (Levine, Robertson, Clare et al., 2000). Although a brief GMT training session did show beneficial effects combined with auditory alerts in Fish et al.'s (2007) study, it is possible that this virtual reality task was more complex and demanding; therefore a more extensive GMT procedure may be required.

It is also possible that the style of delivery of the GMT training may have affected performance, as this study was interested in investigating whether participants were able to generalise from the GMT to benefit from completing the Removals Task. Therefore, in order to avoid simply providing instructional training to participants in ways to achieve optimal performance on the Removals Task (which would not have provided information on their ability to acquire and generalise these skills of their own volition), training was kept broad, using everyday examples to illustrate how this training could be utilised, with only references made to encourage them to think about how they could use this to support the task at hand and to think about their training when the alert sounded. This is quite different from some studies investigating cognitive rehabilitation approaches, for example, Cicerone & Giacino (1992) who provided specific self-instructional training over 5-9 weeks to help participants with TBI complete the Tower of London Task, and from this training reported a generalisation of treatment gains to everyday behaviours. In a recent review investigating interventions for individuals with executive dysfunction, it was reported that while all fifteen studies identified reported some positive immediate treatment outcomes, there was a lack of evidence that the trained approaches generalised to untrained activities or contexts, with any reports of generalisation often being subjective (Kennedy, Coelho, Turkstra et al., 2008). Therefore, further consideration must be given as to whether GMT delivery should initially focus on being task-specific, and from this, investigate how it can be generalised to other everyday situations.

These findings partially replicate and extend those of Sweeney et al. (in press) who found no improvement using alerts but who had hypothesised that further training may have been required to see benefits; in this study, no significant improvement was found combining GMT and alerts on the majority of measures (apart from the sub-group who showed improvement on the Intrusion II measure). As Manly et al. (2002) reported improvements for participants completing the Hotel Task using auditory alerts, Sweeney et al. had hypothesised that individuals may need to have a certain level of intact functioning in order to benefit from the alerts intervention, as their own participant group (with a mean DEX score of 38.5) had been more impaired than Manly et al.'s (mean DEX of 29.6) on the DEX independent-rating measure of executive functioning. However, this study has revealed that the current participants who showed a similar level of executive functioning to Manly et al.'s group as rated by this measure failed to benefit from alerts on the majority of measures on the Removals Task.

There are now three studies reporting different findings on some measures for individuals with executive dysfunction completing the Removals Task/ Bungalow Task in standard non-alerted conditions. The current study, Sweeney et al. (in press) and Kotitsa et al. (who used the "Bungalow Task" – with demands similar to the Removals Task; 2002) report similar findings on the time-based PM task, with brain-injured participants showing impairment in standard, non-alerted conditions. However, while Kotitsa et al. and Sweeney et al.'s participants' demonstrated impairment on the rule-break and strategy scores measures, these findings were not replicated in the current study. Kotitsa et al. were the only study to report impairment on the event-based PM measure: remembering to label fragile items; while the current study found differences between individuals with executive dysfunction and healthy controls on type II intrusions and the number of rooms visited. Therefore, possible reasons for these mixed findings must be considered.

Differences in participants' functioning may account for some of the variable performance observed between studies using the Removals Task. The current group and Sweeney et al.'s experimental group differed on one measure of executive functioning; with Sweeney et al's group rating themselves as experiencing more executive functioning difficulties. However, this is a difficult finding to interpret, as it is known that individuals with more severe executive dysfunction may lack insight into their difficulties (Lezak, Howieson & Loring, 2004) and correspondingly, may rate themselves as lower on these measures; while individuals with a degree of intact functioning have more insight into their difficulties, therefore, there is the possibility that they will achieve higher self-rated impaired scores. In addition to this, scores obtained from relatives who independently rated the level of impairment in both findings did not reveal a significant difference; therefore it is possible that the group did not vary enough to adequately explain these differences in performance.

Another possible reason for differences may be the way that impairments are captured by the Removals Task. Both groups in the current study had similar performance on the activity-based measure: remembering to close room doors, however, it was observed that brain-injured participants were more likely to close *all* the room doors, even when reminded that it was only certain doors they had to close, therefore showing a more cumbersome, inefficient strategy. In addition to this, while the brain-injury and control groups had comparable performance on strategy scores, participants in the brain-injury group did visit more rooms and left behind more furniture that had to be collected at the end of the task. This suggests that while they may have been able to formulate a reasonable overall plan for searching the rooms, they still demonstrated goal neglect and possible impulsivity, showing a more disorganised pattern. Furthermore, it is possible that the way the strategy score is calculated did not show up these impairments in search strategies. During scoring, it is only the pattern of visiting rooms for the collection of furniture for the first three categories that is calculated; however, recorded data and experimenter observations note that while many participants were able to state a reasonable search plan and adhere to this for a short while; they became more disorganised as the task continued (and this is reflected in their score for number of rooms visited). In summary, it is possible that the Removals Task is capturing similar impairments in executive functioning on different measures for different participants, and that some indicators of impairment are not being detected by the task measures. Therefore, based on these findings, further work on the Removals Task may be required to improve the sensitivity and specificity to deficits in everyday planning.

Sweeney et al. (in press) concluded that while the Removals Task has good face validity, i.e. the participants could understand instructions and carry out the basic task requirements, sensitivity of the task was modest on rule break and time-based PM scores, with just over half their clinical sample scoring in the impairment range. Furthermore, while the current study found significant correlations between the PRMQ (prospective memory section) and DEX (self-rated; r = .782) and PRMQ and 6 elements task (r = -.486) no correlations were seen between executive functioning ratings and any of the Removals Task measures. Therefore, these findings concur with Sweeney et al. (in press); further research is required to establish construct and ecological validity. At the moment, the Removals Task is not able to detect executive functioning difficulties in a reliable manner which would enable its use as a potential cognitive rehabilitative assessment tool.

Nevertheless, these findings do support previous studies which have demonstrated the Removals Task's ability to detect some differences in performance between individuals with executive functioning difficulties and healthy controls. There are also the benefits the task offers as a way of looking at several constructs at the same time, allowing one to investigate what the individual shows impairment on, as well as what they can do well. Furthermore, the task offers possible insight into the individual's coping strategies (e.g. closing all room doors, though time-consuming, meant that they were less likely to experience prospective memory failures on this task – this may reflect their strategies in everyday life). Indeed, Burgess, Alderman, Evans et al. (1998) have argued that the behavioural and cognitive sequelae seen in executive dysfunction means that tests measuring different aspects of the syndrome offer greater ecological utility than measures which simply give an overall severity of deficit score. Furthermore, several studies have outlined the benefits of using virtual reality to investigate executive dysfunction, in that it affords levels of experimental control often not possible in “real world’ tasks (e.g. Kotitsa et al., 2002; Priore, Castelnuovo & Liccione, 2002; Rizzo, Schultheis, Kerns & Mateer, 2004).

Therefore, if researchers can determine what exactly the Removals Task is capable of detecting, and validity and reliability can be strengthened, it is argued that this measure still has the opportunity to be an ecologically valid way of assessing executive functioning.

Auditory alerts and Goal Management Training

What of the efficacy of alerts and/or GMT as cognitive rehabilitation tools? While previous studies utilising different tasks have shown benefits of auditory alerts for improving performance in individuals with executive functioning difficulties (Manly et al., 2002; Fish et al., 2007), auditory cueing has not been found to benefit performance on the Removals Task. Sweeney et al. (in press) proposed that differing cognitive demands for the Removals Task and the Hotel Task utilised by Manly et al. (2002) may account for differences in ability to benefit from alerts. Other possible reasons for failure to benefit from the alerts have already been discussed.

Following a review of cognitive rehabilitation studies, Cicerone, Dahlberg, Kalmar et al. (2000) concluded that training in formal problem-solving strategies and the application of techniques to adaptive behaviour and everyday problem situations was a recommended practice for treatment of TBI (McDonald et al., 2002). Furthermore, in a recent systematic review of the cognitive rehabilitation literature for executive functions, GMT is one of a number of cognitive rehabilitation approaches which have been shown to improve problem-solving, etc. for personally relevant activities/ problem situations by using step-by-step approaches, aiming to improve self-monitoring while performing an activity (Kennedy et al. 2008). As discussed earlier, these approaches tend to focus on training the individual on a specific task, before investigating ability to generalise this approach to other areas, therefore, this should be taken into account when considering future GMT approaches involving the Removals Task. Indeed, the promising results for the 6 participants who showed improvements in the Intrusion II measure in alerted conditions highlight the need to continue to investigate GMT's applicability in this setting.

Limitations of this study

Several limitations of this study have been noted already, such as the brevity of the GMT programme, and low sensitivity of the Removals Task to reliably detect differences in performance. Furthermore, it is possible that the recruitment method of the current study influenced the representativeness of the sample. Though recruitment occurred through clinical/ vocational rehabilitation teams working with the majority of participants, there were a number of individuals who volunteered to participate of their own volition. Therefore, it is possible that this was a less impaired sub-group, who had intact planning, organisational and prospective memory abilities enough to remember to post reply forms, and attend sites at the designated appointment times. A further limitation may have been that recruitment for the present study was kept broad – though measures of executive functioning were used, inclusion was based more on the judgement of clinicians, relatives and the individual themselves of their own experienced difficulties.

Final Conclusions and Recommendations for future research

This study has shown that the Removals Task was capable of detecting differences in performance between individuals with executive functioning difficulties and healthy controls on measures of time-based PM, number of rooms visited, type II intrusions made, and overall completion time. Though significant results were noted for a sub-group of participants on one measure, goal management training and auditory cueing did not improve performance for the brain-injured group on the majority of task measures. Ceiling effects, the brevity of the GMT intervention and possible paradoxical effects of the alerts on some measures are discussed as possible reasons for no significant differences being observed. Furthermore, the reliability of the Removals Task to detect executive impairments and its efficacy as a potential cognitive rehabilitative assessment tool is discussed in light of the differing findings which have been reported between studies.

Kennedy et al. (2008) describe the fact that disorders of executive functions are as heterogeneous as the TBI population itself; therefore, it may be that the Removals Task is only capable of detecting selective impairments which have not been clarified as yet. Future research, with stricter inclusion criteria to enable the recruitment of participants with specific detailed impairments may be required to consider what difficulties are detected, and who may benefit from alerts. GMT is showing promise as a cognitive rehabilitation tool for individuals with executive dysfunction, and while several procedural difficulties were highlighted in the present study, using a more extensive GMT programme, one may yet see additional benefits of this approach on the Removals Task, either alone or when combined with auditory cues.

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Figure 1 **Overhead view of Furniture Storage Unit**

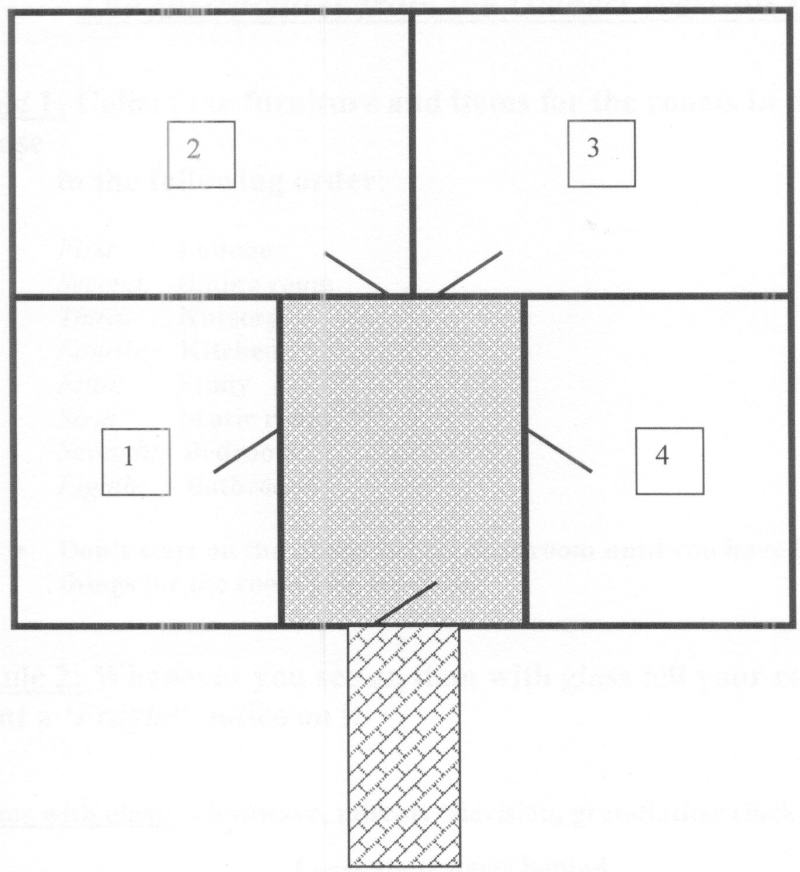
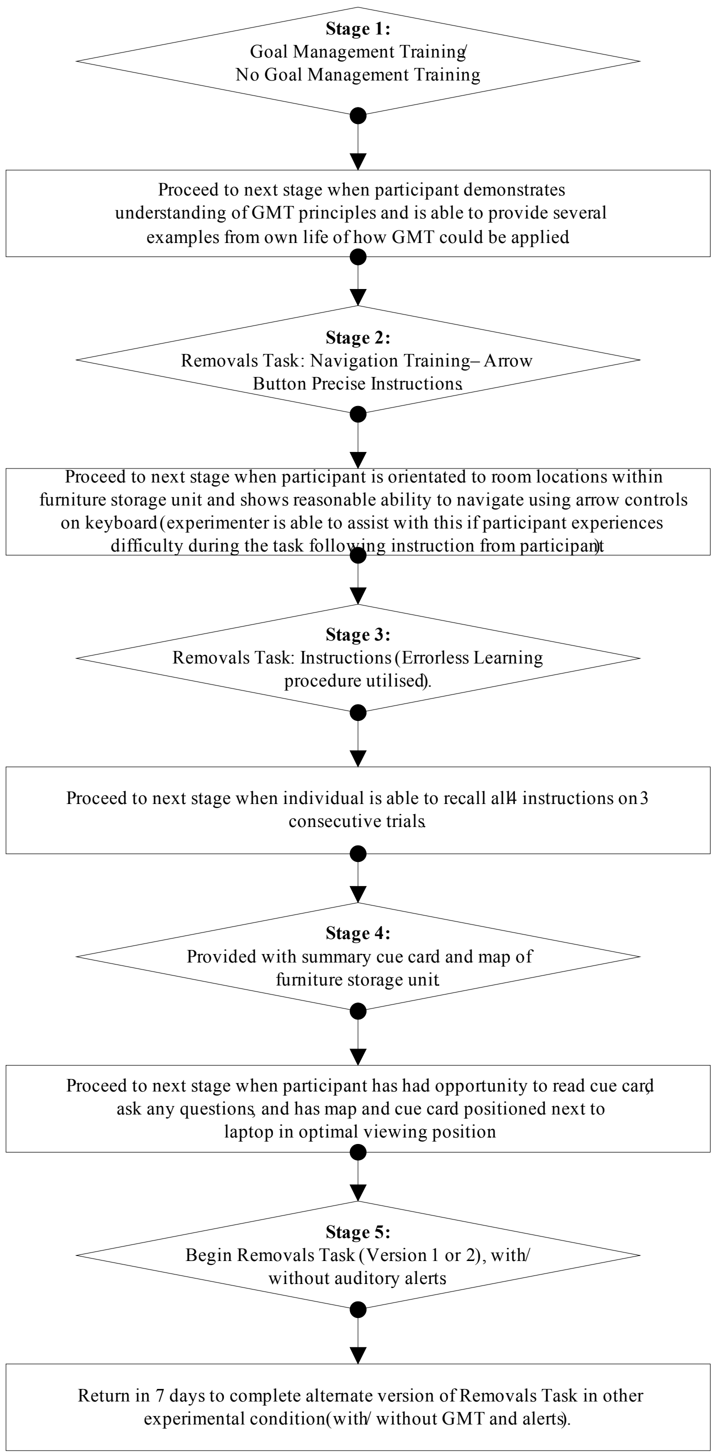


Figure 2 Removals Task Procedure Flowchart

Pre-experimental measures completed by brain-injury group: WTAR, DEX, 6 Elements Task, LM sub-test, RCFT, PRMQ.



* *The control group completed the WTAR and Stages 2-5 once, in standard, non-alerted conditions.*

Table 1: Characteristics of the brain-injury group

	Participants																				Mean	S.D.
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**		
Age (years)	19	43	45	27	55	53	36	48	46	43	57	65	52	26	44	48	65	50	50	53	46.3	11.9
Aetiology*	1	2	1	1	1	2	1	2	1	2	1	1	2	1	1	1	2	1	1	1	-	-
WTAR	91	108	95	87	94	117	106	96	78*	92	119	84*	96	94	90	119	110	110	99	97	101.1	10.4
Time since injury (years)	2	1	14	1	2	2	17	2	14	2	9	11	18	2	3	12	4	25	3	28	8.6	8.4
DEX self	53	29	30	27	66	12	25	17	35	46	12	46	51	35	29	26	13	26	1	19	29.9	16.2
DEX independent	51	32	-	-	64	5	-	42	59	35	4	39	56	-	-	15	6	25	12	39	32.4	20.4
Modified 6 Elements	2	4	2	3	3	4	4	4	4	4	4	2	3	2	1	4	4	3	4	3	3.2	0.95
PRMQ Self	63	45	-	-	76	56	47	55	52	52	40	55	59	55	-	54	31	46	29	51	50.9	11.2
PRMQ Self (Prospective)	32	24	-	-	41	31	25	24	28	25	18	28	30	30	-	28	17	23	13	27	26.1	6.4
PRMQ Proxy	66	44	-	-	73	31	52	31	69	34	32	48	71	58	-	38	26	39	29	57	46.9	16.1
PRMQ Proxy (Prospective)	34	26	-	-	38	17	27	18	36	16	19	23	35	32	-	23	12	20	14	29	24.6	8.3
LM 1 (%ile)	21	74	47	26	26	26	26	47	32	47	47	32	42	26	21	74	74	47	16	21	38.6	18.3
LM 2 (%ile)	32	79	53	37	47	37	37	58	47	58	58	47	47	5	32	63	74	53	32	21	45.8	17.5
LM Recognition (%ile)	97	97	67	67	87	70	77	87	90	97	90	90	77	73	70	100	93	80	97	70	83.7	11.5
RCFT Immediate (%ile)	1	86	-	8	12	14	27	90	1	38	98	-	1	1	1	82	90	79	21	1	36.2	38.8
RCFT Delayed (%ile)	2	88	-	7	2	16	21	31	1	46	99	-	1	1	1	46	97	18	14	1	27.3	34.3

Aetiology* 1 = Traumatic Brain Injury, 2 = Cerebrovascular Injury (e.g. Sub-arachnoid haemorrhage, aneurysm, stroke)
WTAR: * = score not included in overall mean as not indicative of actual functioning - tendency to give up/pass on items/ language impairment
- questionnaire not completed

Table 2: Brain-injury vs. Control group in standard, non-alerted condition

No GMT or AA	Mean (SD) *Median (range)*		*t/z/U*	*p*	Effect Size r
	Brain-Injury	Control			
Rule Break	*7 (5-7)*	*7*	*U*(161.5)	0.428	0.26
Strategy Score	*32 (18-36)*	*30 (16-36)*	*U*(137.5)	0.14	0.23
Activity-based PM (closing room doors)	*0 (0-7)*	*0 (0-1)*	*U*(157.5)	0.365	0.25
Event-based PM (fragile items)	5.8 (2.7)	6.3 (2.2)	*t*(0.979)	0.334	0.16
Intrusions I	*0 (0-11)*	*0 (0-2)*	*U*(150.5)	0.19	0.21
Intrusions II	*0 (0-3)*	*0*	*U*(133)	0.01*	0.37
Time-Based PM (seconds)	116.2 (75.2)	72.8 (49.9)	*t*(2.11)	0.042*	0.32
Initial front door close	*0 (0-1)*	*0 (0-1)*	*U*(188)	0.967	0.01
Completion Time (seconds)	1755.4 (613.4)	1267.42 (544.8)	*t*(2.62)	0.013*	0.39
Number of rooms visited	31.75 (8.5)	26.6 (4.83)	*t*(2.3)	0.027*	0.35

* statistically significant findings (p<0.05, two-tailed)

Table 3: Correlations between selected measures on the Removals task and other measures of executive functioning

Measures	DEX	Modified 6 elements	PRMQ (prospective memory section)
Strategy Scores	rho = .088, p = .713	rho = .019, p = .937	rho = .209, p = .420
Time-based PM	r = .093, p = .698	r = .050, p = .835	r = .265, p = .304
Intrusions II	rho = -.063, p = .792	rho = -.145, p =.542	rho = -.079, p = .762
Activity-based PM: no. of rooms visited	r = -.214, p = .365	r = .085, p = .721	r = -.270, p = .295

Table 4: Brain-injury group - Practice effects from 1st to 2nd trial (irrespective of GMT/ AA condition)

No GMT or AA	Mean (SD) *Median (range)*		*t/z/U*	*p*	Effect Size r
	1st trial	2nd trial			
Rule Break	*7 (5-7)*	*7 (5-7)*	*z* (0.28)	0.78	0.05
Strategy Score	*28 (14-36)*	*32 (19-36)*	*z* (1.31)	0.19	0.19
Activity-based PM (closing room doors)	*0 (0-1)*	*0 (0-1)*	*z*(-1.725)	0.084	0.1
Event-based PM (fragile items)	4.55 (3.33)	5.65 (2.5)	*t*(1.24)	0.23	0.18
Intrusions I	*0 (0-3)*	*0 (0-11)*	*z* (-0.287)	0.774	0.12
Intrusions II	*0 (0-3)*	*0 (0-2)*	*z*(-0.172)	0.863	0.03
Time-Based PM (seconds)	131.8 (87)	112.4 (64.8)	*t*(1.19)	0.249	0.13
Initial front door close	*0 (0-1)*	*0 (0-1)*	*z* (0)	1	0.11
Completion Time (seconds)	1822 (581.9)	1590 (625.8)	*t*(2.65)	0.016*	0.19
Number of rooms visited	30.6 (6.38)	30.1 (7.76)	*t*(0.368)	0.717	0.04

* statistically significant findings (p<0.05, two-tailed)

Table 5: Brain Injury group: GMT & AA (vs. No alerts)

No GMT or AA	Mean (SD) *Median (range)*	*t/z/U*	*p*	Effect Size r
Rule Break	*7 (5-7)*	*z*(0.27)	0.39	0.05
Strategy Score	*28 (14-36)*	*z*(1.567)	0.117	0.23
Activity-based PM (closing room doors)	*0 (0-8)*	*z*(0.288)	0.774	0.02
Event-based PM (fragile items)	4.5 (3.1)	*t*(1.91)	0.071	0.22
Intrusions I	*0 (0-3)*	*z*(0.862)	0.389	0.17
Intrusions II	*0 (0-2)*	*z*(1.04)	0.3	0.17
Time-Based PM (seconds)	128.05 (79)	*t*(0.774)	0.484	0.08
Initial front door close	*0 (0-1)*	*z*(1)	0.317	0.11
Completion Time (seconds)	1656.8 (614.1)	*t*(0.986)	0.337	0.08
Number of rooms visited	29.7 (7.1)	*t*(1.32)	0.2	0.13

Table 6: Comparison of 10 participants who completed no GMT/AA condition in first trial and GMT/AA 2nd trial

No GMT or AA	Mean (SD) *Median (range)*		*t/z/U*	*p*	Effect Size r
	1st trial	2nd trial			
Rule Break	*7 (6-7)*	*7 (5-7)*	*z*(0.378)	0.71	0.09
Strategy Score	*30 (18-36)*	*29 (19-36)*	*z*(0.281)	0.778	0.02
Activity-based PM (closing room doors)	*0 (0-1)*	*1 (0-3)*	*z*(1.89)	0.059	0.39
Event-based PM (fragile items)	5.1 (3.07)	5.2 (3.01)	*t*(0.071)	0.945	0.02
Intrusions I	*0 (0-3)*	*0 (0-3)*	*z*(-0.184)	0.854	0.05
Intrusions II	*0 (0-3)*	*0 (0-1)*	*z*(-0.816)	0.414	0.18
Time-Based PM (seconds)	126.8 (64.4)	123.6 (80.62)	*t*(0.148)	0.886	0.02
Initial front door close	*0 (0-1)*	*0 (0-1)*	*z*(0)	1	0.01
Completion Time (seconds)	1819.4 (650.8)	1613.3 (731)	*t*(1.29)	0.231	0.15
Number of rooms visited	29.7 (4.97)	27.8 (7.93)	*t*(0.814)	0.437	0.14

Chapter 3: Advanced Clinical Practice I Reflective Critical Account

Seeing the Whole Picture: Understanding the Contribution of Organisational Issues to Role Conflict within a Multidisciplinary Team

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Abstract

Health and social care policies have highlighted the importance of integrated working and effective team functioning. The British Psychological Society has emphasised the important role that clinical psychologists have to offer in contributing to multidisciplinary working. However, the potential for conflict has been illustrated in a conceptual model (Weaver, 2008) and organisational issues that can impact on team dynamics and successful multidisciplinary collaboration have been identified. This reflective account describes my experience of role conflict and how I was able to make sense of this experience through developing a complex formulation taking into account the organisational context in which this occurred. I also explore how my own reflective practice changed through this process, and discuss my experience of utilising supervision. The impact of this learning experience on my development and future practice is identified and potential issues for clinical psychologists working in multidisciplinary teams are highlighted.

Full chapter bound separately in Volume 2 of Thesis

Appendix 4: Advanced Clinical Practice II Reflective Critical Account

Considering the role of Clinical Psychology within an In-patient Setting

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Abstract

The way that clinical psychologists work is changing, with professional establishments promoting a consultative model of clinical psychology service provision to multidisciplinary teams (BPS, 2007a). Integrated working is now a common aspect of the clinical psychologist's work, nevertheless, the role and structure of this service delivery can vary across settings. This account describes my experience of starting placement in an in-patient unit, and how I began to question the role of clinical psychology within this context. Schön's (1991) reflective model is used to describe my initial feelings and experiences, while Kolb's learning cycle (1984) is used to describe how I began to make sense of these experiences through the process of supervision. This account then reflects upon the wider role of clinical psychologists' within mental health services, considering the different models of service delivery, and uses a grounded theory framework (Dilks, Smith, Doherty et al., 2009) to discuss identified advantages and challenges to integrated working. The main learning points from these reflections are discussed, as well as how they have impacted on my own professional development.

Full chapter bound separately in Volume 2 of Thesis

Appendix 1.1 Guidelines for submission to *Neuropsychological Rehabilitation*

Please email your paper to the editorial assistant, saved in a standard document format type such as Word or PDF, at camilla.barnard@psypress.co.uk. You may also contact the Editorial Assistant by phone on (0)2070 177419.

Your covering email must include full contact details (including email), the title of the journal to which you are submitting, and the title of your article.

All manuscripts must be accompanied by a statement confirming that it has not been previously published elsewhere and that it has not been submitted simultaneously for publication elsewhere.

All manuscripts should be submitted in American Psychological Association (APA) format following the latest edition of *Publication Manual of the APA* (currently 5th edition).

Authors will normally receive a decision on their papers within three months of receipt, and if accepted they will normally be published six to nine months later. The date of receipt of the manuscript will be printed. Where minor revision of a paper is requested the original date of receipt will appear, provided that a satisfactory revision is received within one month of the request. Otherwise it will bear the revised version date.

Journal Production Editor: authorqueries@tandf.co.uk

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Typescripts. The style and format of the typescripts should conform to the specifications given in the *Publication Manual of the American Psychological Association* (5th ed.). Typescripts should be **double spaced** with adequate margins, and numbered throughout. The title page of an article should contain only:

(1) the title of the paper, the name(s) and address(es) of the author(s);

(2) a short title not exceeding 40 letters and spaces, which will be used for page headlines;

(3) name and address of the author to whom correspondence and proofs should be sent;

(4) your telephone, fax and e-mail numbers, as this helps speed of processing considerably.

(5) 3-5 keywords

Abstract. An abstract of 50-200 words should follow the title page on a separate page.

Headings. Indicate headings and subheadings for different sections of the paper clearly. Do not number headings.

Acknowledgements. These should be as brief as possible and typed on a separate page at the beginning of the text.

Permission to quote. Any direct quotation, regardless of length, must be accompanied by a reference citation that includes a page number. Any quote over six manuscript lines should have formal written permission to quote from the copyright owner. It is the author's responsibility to determine whether permission is required from the copyright owner and, if so, to obtain it. (See the bottom of the page for a template of a letter seeking copyright permission.)

Footnotes. These should be avoided unless absolutely necessary. Essential footnotes should be indicated by superscript figures in the text and collected on a separate page at the end of the manuscript.

Reference citations within the text. Use authors' last names, with the year of publication in parentheses after the last author's name, e.g., "Jones and Smith (1987)"; alternatively, "(Brown, 1982; Jones & Smith, 1987; White, Johnson, & Thomas, 1990)". On first citation of references with three to six authors, give all names in full, thereafter use first author "et al.". If more than one article by the same author(s) in the same year is cited, the letters a, b, c etc. should follow the year.

Reference list. A full list of references quoted in the text should be given at the end of the paper in alphabetical order of authors' surnames (or chronologically for a group of references by the same authors), commencing as a new page, typed double spaced. Titles of journals and books should be given in full, e.g.:

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Baddeley, A. D. (1999). *Essentials of human memory.* Hove, UK: Psychology Press.

Chapter in an edited book:

Plomin, R., & Dale, P. S. (2000). Genetics and early language development: A UK study of twins. In D. V. M. Bishop & L. B. Leonard (Eds.), *Speech and language impairments in children: Causes, characteristics, intervention and outcome* (pp. 35-51). Hove, UK: Psychology Press.

Journal article:

Schwartz, M. F., & Hodgson, C. (2002). A new multiword naming deficit: Evidence and interpretation. *Cognitive Neuropsychology, 19,* 263-288.

Tables. These should be kept to the minimum. Each table should be typed double spaced on a separate page, giving the heading, e.g., "Table 2", in Arabic numerals, followed by the legend, followed by the table. Make sure that appropriate units are given. Instructions for placing the table should be given in parentheses in the text, e.g., "(Table 2 about here)".

Figures. Figures should only be used when essential. The same data should not be presented both as a figure and in a table. Where possible, related diagrams should be grouped together to form a single figure. Figures should be drawn to professional standards and it is recommended that the linear dimensions of figures be approximately twice those intended for the final printed version. Each of these should be on a separate page, not integrated with the text. Figures will be reproduced directly from originals supplied by the author(s). These must be of good quality, clearly and completely lettered. Make sure that axes of graphs are properly labelled, and that appropriate units are given. Photocopies will reproduce poorly, as will pale or broken originals. Dense tones should be avoided, and never combined with lettering. Half-tone figures should be clear, highly-contrasted black and white glossy prints.

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The figure captions should be typed in a separate section, headed, e.g., "Figure 2", in Arabic numerals. Instructions for placing the figure should be given in parentheses in the text, e.g., "(Figure 2 about here)". More detailed *Guidelines for the Preparation of Figure Artwork* are available from the publisher: Psychology Press Ltd, 27 Church Road, Hove, East Sussex BN3 2FA, UK (Email: authorqueries@tandf.co.uk).

Statistics. Results of statistical tests should be given in the following form:

"... results showed an effect of group, $F(2, 21) = 13.74$, $MSE = 451.98$, $p < .001$, but there was no effect of repeated trials, $F(5, 105) = 1.44$, $MSE = 17.70$, and no interaction, $F(10, 105) = 1.34$, $MSE = 17.70$."

Other tests should be reported in a similar manner to the above example of an F -ratio. For a fuller explanation of statistical presentation, see pages 136-147 of the *APA Publication Manual* (5th ed.). For guidelines on presenting statistical significance, see pages 24-25.

Abbreviations. Abbreviations that are specific to a particular manuscript or to a very specific area of research should be avoided, and authors will be asked to spell out in full any such abbreviations throughout the text. Standard abbreviations such as RT for reaction time, SOA for stimulus onset asynchrony or other standard abbreviations that will be readily understood by readers of the journal are acceptable. Experimental conditions should be named in full, except in tables and figures.

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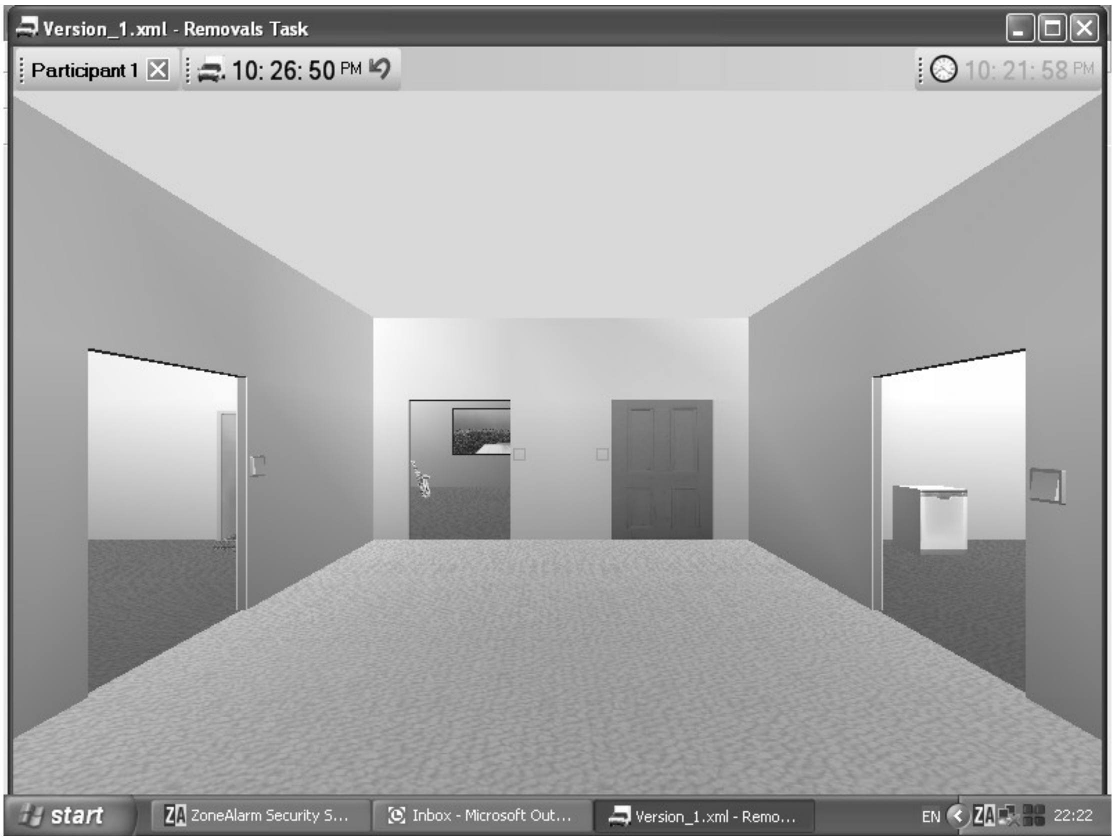
Appendix 1.2 **Quality Assessment Checklist**

Quality Item	**Rater 1 / 2**
<u>Statistical Conclusion Validity:</u>	
1. Is a power calculation reported or effect sizes described for the main variables being investigated?	Yes (1) No (0)
2. Is there possibility of violation of assumptions of statistical tests?	No (1) Not enough information to evaluate (0) Yes (0)
3. Is there increased possibility of Type I error?	No (1) Yes (0)
<u>Internal Validity:</u>	
4. Standardised procedural protocol/ variations or confounds in length of training across conditions (e.g. is there evidence that different procedures/ protocols were introduced within/ between groups/ conditions?)	No [not a threat] (1) Not enough information to evaluate (0) Yes [definitely a threat] (0)
5. Any possible outcomes measured using standardized measure?/ Used psychometrically sound measures - Not a threat = Objective, standardised measure (not self-report) Definitely a threat = subjective (e.g. self-report), or non-standardised measure e.g. in priming experiments, taking words which have already been normed and categorized according to frequency, etc. Using treatment protocol which have been implemented in previous studies. Or stating that stimuli have already been piloted, etc.	Yes [not a threat] (1) Not enough information to evaluate (0) No [definitely a threat] (0)

6. Instrumentation (e.g. ceiling or floor effects) Not a threat – have acknowledged ceiling/floor effects and accounted for this in any further analyses.	No [not a threat] (1) Not enough information to evaluate (0) Yes [definitely a threat] (0)
7. Introducing randomization in conditions whenever possible (e.g. evidence of counterbalancing)	Yes (1) Not enough information to evaluate (0) No [definitely a threat] (0)
8. Pre-study assessment - Are other head injuries reported? (e.g. TBI caused by falls/ injury while intoxicated?) Or Is there any supporting neuro-imaging evidence/ or details taken from medical notes of specific areas of the brain damaged? or is neuro assessment completed?	Yes (1) No (0)
9. Pre-study assessment of alcoholic control group	Yes (1) No (0)
<u>Construct Validity:</u>	
10. Inadequate pre-operational explication of constructs	No [not a threat] (1) Not enough information to evaluate (0) Yes [definitely a threat] (0)
11. Is the study methodology described in such a way that replication is possible?	Yes (1) Not enough information to evaluate (0) No (0)
12. Are limitations of the study acknowledged? Adequate = serious threats to validity are acknowledged and plausible rival explanations discussed Inadequate = no possible limitations acknowledged, or only ancillary limitations noted when larger confounding variables/ more serious threats to validity are present.	Adequate (1) No, or Inadequate (0)

Experimental Group Characteristics: **13. Have alcoholic control participants been abstinent for at least 4 weeks?**	Yes (1) No (0)
External Validity: 14. **Detailed recruitment methods - Are inclusion and exclusion criteria adequately described?** Adequate = clearly describes how participants recruited Inadequate = states where participant recruited from (e.g. day hospital, in-patient, etc) no description of how recruited.	Adequate (1) Not enough information to evaluate (0) Inadequate (0)
15. Use of participants from previous experiments treated as new sample? Adequate = subsequent experiments keeping all the same KS participants (remaining within-groups) or using completely new KS sample/ scored as 1 if only one experiment in study Inadequate = subsequent experiments recruit some new KS participants and retain several from previous experiments	No (1) Not enough information to evaluate (0) Yes (0)

Appendix 2.1 Internal view of hall and one of the rooms




Version_2.xml - Removals Task
Participant 2
10: 28: 50 PM
10: 23: 59 PM
start
ZoneAlarm Secur...
Inbox - Microsof...
Document1 - Mic...
Version_2.xml - ...
EN
22:24

Appendix 2.2 Experimental Measures – scoring for Rule break and Strategy scores

Rule Break Score: Participants were told that there are eight rooms in the new house and they must collect furniture and items for these rooms in a specific order. From this, a rule break score was then calculated according to whether participants followed the specified room order for collecting furniture. To obtain a rule break score, the eight rooms of the new house are designated as categories (shown below), and the actual order that the participant followed for collecting furniture was recorded.

Version 1: Room	Category	Version 2: Room	Category
Lounge	1	Study	1
Dining room	2	Bathroom	2
Nursery	3	Kitchen	3
Kitchen	4	Music Room	4
Study	5	Lounge	5
Music Room	6	Bedroom	6
Bedroom	7	Nursery	7
Bathroom	8	Dining Room	8

The order of collecting furniture from each room/category was calculated separately; then scores are added up to give a total 'rule break' score. Each room order completed correctly scores 1 point, and the maximum **rule break score = 7** (8-1) reflecting good adherence to the rule and no rule breaks (Kotitsa et al., 2002).

Strategy score: This was calculated for each participant looking at the efficiency of their strategy for collecting furniture. Using a control group, Morris et al. (2002a) identified two dominant search strategies for visiting the rooms in the bungalow looking for items to collect.

The 1234 Model strategy – When looking for furniture to collect for a particular category (room of the new house), this strategy involves visiting room number 1 first, then room 2, room 3, and lastly, room 4. Moving on to the next category (i.e. room of the new house) would involve repeating this cycle again.

The 1432 Model strategy – Alternatively, some control participants were observed to visit room 4 after room 1, then room 3, and lastly, room 2. As stated by Morris et al. (2002), these two strategies were not part of the instructions, but emerged spontaneously in normal subjects as an efficient way of completing the task. To compute the strategy score measure, the exact pattern of visiting rooms was recorded and scored using the displacing method described below:

Points are awarded for search strategies for the first 3 categories (rooms collected for) e.g. in Version 1, this would be the lounge, dining room and nursery (categories 1, 2 and 3, respectively). Deviations from these patterns resulted in points being deducted. Only strategy scores for the first 3 categories were calculated as the pattern of dispersal of the remaining furniture items around the rooms would not justify the continuation of this sequencing strategy (Kotitsa et al., 2002). Therefore, for scoring purposes, restriction to the first 3 categories was considered appropriate by Morris et al. (2002b) and was adopted here.

EXAMPLE: A participant was completing version 1 and demonstrated the following room search order:
Collecting for the Lounge (category 1) first: Room 1, room 2, room 4, room 3, room 2, room 1
Dining room (category 2): room 1, 3, 2
Nursery (category 3): room 1, 2, 4, 3, 4

Scoring these, the first four visits for each category are taken into account; while extra visits are ignored (failure to visit a room would be scored as 0). These visits are then scored according to the two model strategies detailed above, also taking account of any displacements. The highest score for each room visit can be 3, reflecting the order of one of the models above, with no displacement.
Maximum score for the 4 room visits is therefore 12 points (3 points each for room visit in order 1,2,3,4 or 1,4,3,2). Maximum displacement from these models was by 3 rooms (which would score 0). A displacement score of 2 (i.e. losing one point) would be given when the room visited was displaced by one position in relation to the model sequencing (Morris et al., 2002b), e.g. 1,3,2,4 for the 1234 model, or 1,3,4,2 for the 1432 model. A displacement score of 1 would be given when the room visit was displaced by 2 positions relative to the model sequence (and as mentioned, 0 points would be given if displaced by the maximum – 3 positions).

Therefore, in the example given above, points would be awarded on the basis of the 1234 search strategy as such:

for category 1 (Lounge): room 1 (3), room 2 (3), room 4 (2), room 3 (2) (room 2 and room 1 at end are discarded) = 10 points.
Then dining room (category 2): room 1 (3), room 4 (1), room 2 (1) = 5 points
then nursery (category 3): room 1 (3), room 2 (3), room 3 (3), room 4 (3) = 12 points

All 3 scores are then added up to produce the '1234-strategy' measure of 27 points out of maximum 36. To account for the possibility that the participant may be using the 1432-strategy, scores for each category are also calculated for this model, using the procedure above, giving a total score of 24 out of 36 (8 for category 1, 8 for category 2, and 8 for category 3). The highest strategy score from either model was taken as the participant's strategy score.

Appendix 2.3 Arrow button precise instructions

The participant should be observing the experimenter.

The experimenter says: “These are the arrow buttons; if I press this one [*demonstrate*] you can see you will move forward towards the storage unit. If I press this one [*demonstrate*] you can see you are moving backwards away from the storage unit.”

“Now have a go for yourself. Use your preferred hand. Now press the forward arrow button to move forward. Now press the backwards arrow button to move back.

If the participant is successful go on to the next stage. If the participant has difficulty, demonstrate the movement again. Keep demonstrating until you are satisfied that the participant can move backwards and forwards.

<u>*Prompts*</u>:

Make sure that you only press the forwards and backwards arrow buttons.

Don’t press the left or right arrow buttons.

Next, the experimenter should demonstrate the left and right movement. Say to the participant:
“to turn left, I press the left pointing arrow; to turn right, I press the right pointing arrow. You can see how the view changes.”

Then, ask the participant to have a go.

Try pressing the right pointing arrow button ………………. And then the left.

Repeat the demonstration if they have difficulty, and the instructions for practice.

<u>*Prompts*</u>:

Press the right arrow, press the left arrow.

Don’t press the forwards or backwards arrow at this stage.

Next phase is to move forward towards the door. “Now try moving forward to the door.”

When the participant is close to the door, say “Stop”. *After a short pause*, say “now press the backwards button to move back a bit.” *After a suitable distance*, say “Stop”. *After a pause, say* “Now look to the left” *then after another pause say*, “Now look to the right.”

Appendix 2.4 Navigation instructions

(Example navigation instructions for Version 1)

Instruct the participant to move forward close to the door again. "Now move forward close to the door."

Instruct the participant about opening the door "to open the door, touch the door switch with the index finger [demonstrate] of the same hand that is using the arrow button keys." After a pause, say "Now put your hand back near the arrow button keys…You can see the door is open."

Instruct them to close the door "Now close the door by touching the switch again with your finger."

<u>Prompts:</u>

"The door switch is there" [point to the door switch].
"Now the door is closed again" pause "open the door again".

Repeat the opening and closing of the door as necessary until it is clear that the participant has mastered this procedure.

Now show the participant the map. Instruct the participant: "this is the map of the furniture storage unit….here is the path which leads up to the front door [demonstrate] ….. Go through the front door into the hall….You can then move up the hall and the first door on your left takes you into room number 1, straight ahead is room number 2, ahead to the right is room number 3."

Now take the participant into the hall. "Using the forward arrow button, go ahead, through the front door, into the hall." When the subject has gone into the hall say "stop".

"Ahead of you, you can see three doors, to the left is the first room [point]…look at it on the map [point] ……Ahead is a second one [point] …… look at it on the map [point] ….Ahead to the right is a third door [point] ….there it is on the map [point]."

Then say, "there is the fourth room directly to the right" [point on the VDU the direction and then point on the map].

Instruct the participant about going forward and going into the room one. "Now go forward so that you are in front of the door ahead to the left [point] … I will tell you when to stop ….Stop."

Take the participant forward until they are very close to the door of the room ahead. Now say, "Turn to the left….and you can see the door in front of you now."
"Now open the door and go into the room….Stop."
When the participant is just in the room, tell them to turn to the left to go towards the dolls house "turn to the right to face the chair….go forward….Stop…….then turn all the way round to the right until you see the door then back till you see the dolls house. "This is the room."

Now instruct them to move to just in front of the television. Then instruct them to turn so that they face back to the door.

"Now move to be just in front of the television."
"Now turn all the way around to face the door….Now move forward to be in front of the door."
Use prompts as necessary to ensure that they are facing the right direction and then move towards the door.

Instruct them on how to go through the door.
"Face slightly to the left of the door and go forward until it passes you on the right."
Then turn to face out of the room.
"Now move forward out of the room until I say stop…" "STOP."

Then go ahead to the door you see ahead in the distance.
"Now go ahead and enter room 4" [let them do this on their own but use prompts if necessary].

When they are in the fourth room, tell them to stop and turn to the right.
"Turn to face the bath at the right side of the room [point] and move forward to just in front of it."
Then instruct them to turn around and go back to the entrance to the room. Instruct them as follows:

"When you have reached the entrance, turn to face out of the room."

They should be facing out through the hallway and can see the open room one opposite. Then instruct them to go forward until they are ready to turn to the right to open the door of room 3.

"Go forward a bit"….

Instruct them to turn to the right and open the door.
"Turn to the right to open that door"… "Open the door."

Instruct them to enter the room
"Go ahead until you see the music stand go ahead until you are in front of it as if you are reading it." Now instruct them to turn to face the piano.

“Now turn to the left and inspect the piano “Turn to the right again and look at the oven “Move ahead so that you are standing close to the oven”.
“Turn right to face the door again and then go out into the hallway … you can see the main door in the distance…Now stop [they should stop fairly far away so that they can turn to see room 2 door] …. Now turn right, find the remaining closed door…. Open it and go inside.”

“Turn left and look at the rest of the room….Move forward to just in front of the bed.” They should be just in front of the bed with the window on the right.

“Now turn around and see the room from a different direction. Turn to your left. Now move a bit to the left of the door to go out of the room.”

[They should go fairly close up to the wall and then turn right]

“Now go out into the hallway and go towards the front door…. Turn around until you are looking behind you….”

[Now they should turn around and go out of the building] “Turn around and go out of the building, making sure when you get to the path you turn to go down it….”
[They should go out far enough so that they can turn around and then shut the door]
“Shut the door.”

They have done well, and you can continue with the test, say to the participant: “Well done, that was very good.”

If they have had substantial problems or failed at an early stage, thank them for doing the test and move on to another one but do not do the main procedure.

Appendix 2.4 Removals Task instructions[4]

- "Now you are going to do an imaginary task. The owner of the bungalow *(pointing to virtual bungalow)* is going to move to a larger house and has to move the furniture. You are the removal person and you have to go into the bungalow and get the furniture and some items so that they are ready for the arrival of the removal van. You go into the bungalow and choose the furniture or items by touching them. You will see the things you can fetch because they all have green labels on them, which say *'to go'*. When you choose, the item will disappear; this means that it has been moved outside the house."

The next step is to instruct the participant around the constraint rules and the clock by saying "The owner is a bit fussy and likes the removal to be done in certain ways – there are four main instructions that have been given to you. To help you remember these, they are summarized on this card *(pointing to the cue card)*. I will go through them, but if you have any questions as we go along, please ask."

- **Rule 1**. "Firstly, the owners are going to live in a bigger house with all these rooms *(pointing to the cue card)* …a lounge, dining room, nursery, kitchen, study, music room, the bedroom, and the hallway You have to collect up all the things for each room in the new house in turn – you start with things *(pointing to the card)* for the lounge, then the dining room, then the nursery, the kitchen, music room, bedroom, and hallway. The things in the bungalow *(pointing to the bungalow)* are not all in one room. So you may have to go from room to room to get all the things for, let us say, the lounge. The things for the lounge in the new house will be spread around the different rooms in the bungalow, and you have to go around and find them. Here is the instruction from the owner *(pointing to the card)* … **You should collect all the things for the new lounge first, going round the rooms of the bungalow, then collect the things for the new dining room, then the nursery, the kitchen, the study, the music room, the bedroom, and lastly the hallway.** Don't start on the things for the next room until you have fetched all the things for the room you are doing. Also, you are with a work colleague and each time you are collecting an item you have to tell them which room you are collecting that item for. **Each time say for which room you are collecting an item."**

- **Rule 2.** "The second rule is that the owners *(pointing to the card)* are worried about breaking things and they would like you to put **'*Fragile*'** notices on all the things with glass – to do that touch the item and tell me that you are putting 'Fragile' notices on it. **Whenever you see an item with glass put a '*Fragile*' notice on it.** For example, items with glass

[4] Task instructions replicated from Sweeney et al.'s study (in press)

include the microwave, the computer, television, the wine in the wine rack and the grandfather clock. The owners would like to take these things themselves. **So, leave these items behind."**

- **Rule 3.** "The third rule is about a cat who is still in the bungalow. The owners don't want it to get out of the house, so you have to close the front door when you first enter and later on if you open it. So, **keep the front door closed unless you use it. Also close the door of room 2 <u>not</u> when you are inside the room but each time you <u>leave</u> that room."**

- **Rule 4.** "And the last rule: whilst you are getting the things to put in the garden another work colleague will be coming with the removal van. The front door bell does not work and you might not hear him knock…so you should check the front door every five minutes to see if the van has arrived. You should check this clock *(clock is placed to the right-hand side of the participant)* when you are going in and five minutes later you go back and open the front door to check. **Check the front door every five minutes.** To help you, I will write down the time when you go in the bungalow and also write it down every time you have to go and check the front door."

Appendix 2.6 **Participant instruction cue card (version 1 & 2)**

The Instructions from the Owners (version 1)

Rule 1: Collect the furniture and items for the rooms in the new house in the following order:

First: **Lounge**
Second: **Dining room**
Third: **Nursery**
Fourth: **Kitchen**
Fifth: **Study**
Sixth: **Music room**
Seventh: **Bedroom**
Eighth: **Bathroom**

- **Don't start on the things for the next room until you have fetched all the things for the room you are doing**

Rule 2: Whenever you see an item with glass tell your colleague to put a '*Fragile*' notice on it

Items with glass: microwave, mirror, television, grandfather clock

Leave these items behind

Rule 3: Close the front door immediately if you open it

Close the door of room 2 every time you leave the room

Rule 4: Check the front door every five minutes using your clock

Remember to get the correct time you need to ask your colleague for the correct time.

The Instructions from the Owners (Version 2)

Rule 1: Collect the furniture and items for the rooms in the new house in the following order:

First: **Study**
Second: **Bathroom**
Third: **Kitchen**
Fourth: **Music Room**
Fifth: **Lounge**
Sixth: **Bedroom**
Seventh: **Nursery**
Eighth: **Dining Room**

- **Don't start on the things for the next room until you have fetched all the things for the room you are doing**

Rule 2: Whenever you see an item with glass tell your colleague to put a '*Fragile*' notice on it

Items with glass: monitor, glass table, medicine cabinet, grandfather clock

Leave these items behind

Rule 3: Close the front door immediately if you open it

Close the door of room 3 every time you leave the room

Rule 4: Check the front door every five minutes using your clock

Remember to get the correct time you need to ask your colleague for the correct time.

Appendix 2.7 **Participant invitation letter (brain-injury group)**

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Acute Division
Rehabilitation and Assessment Directorate
Community Treatment Centre for Brain injury
70 Commercial Road
Gorbals
Glasgow.
G5 0QZ

NHS Greater Glasgow and Clyde

UNIVERSITY of GLASGOW

Section of Psychological Medicine, University of Glasgow
Community Treatment Centre for Brain injury, Glasgow

Prospective Memory Study

Dear ………………………………….

I am writing to see whether you would be interested in contributing to a research project that is being jointly carried out by the Community Treatment Centre for Brain Injury and the University of Glasgow.

The project looks at what is called prospective memory – that is remembering to do things at some point in the future (remembering to call a friend at a certain time, to put the bin out on the correct day, remembering to go to an appointment and so on). More details of what would be involved in taking part are given on the attached information sheet but the basics are;

1. For you to attend a session of about no longer than 1 ½ hours when we will ask you to complete 4 short questionnaires and carry out 3 short tasks.
2. Next, we would like you to complete a computer task. The task is called the 'Removals Task' and will involve you taking on the role of a removal person. The task simulates the task of packing up a house for moving to a new house.

3. About 10-14 days later we will ask you to come back to the Community Treatment Centre to carry out a slightly different version of the Removals Task.

We would very much appreciate your involvement in this research but understand that you may not wish to be involved or may have other commitments at this time.

If you are interested in taking part, please return the attached form in the free post envelope or call 07722057723 to set up an appointment with Pamela Brown.

Remember, even if you agree to take part you are completely free to withdraw from the project at any time without needing to give us a reason.

Yours sincerely,

Dr Denyse Kersel	Professor Jonathan Evans	Pamela Brown
Clinical Director	Consultant Clinical Psychologist	Trainee Clinical Psychologist

Appendix 2.8 **Participant information sheet (brain-injury group)**

Acute Division
Rehabilitation and Assessment Directorate

NHS Greater Glasgow and Clyde

UNIVERSITY of GLASGOW

Study - The effects of utilising periodic alerts and goal management training to improve prospective remembering on a virtual reality task.

INFORMATION SHEET

Who is conducting the research?

The research is being carried out by Pamela Brown, Trainee Clinical Psychologist, Professor Jonathan Evans from the Section of Psychological Medicine of the University of Glasgow and Dr Siobhan Sweeney from the Community Treatment Centre for Brain Injury.

What is the research about?

Remembering to do things in the future (e.g. remembering to post a letter on the way home, to send a birthday card to a relative at the right time or to attend an appointment) is difficult and most people make mistakes from time-to-time. People often say that they have more problems with this type of memory following certain types of neurological illness or injury. We are looking at ways of improving our understanding of this type of problem and ways of improving rehabilitation strategies that may help reduce mistakes. The research we are carrying out is investigating whether auditory alerts (in the form of beeps) and a short training (called goal management training) can improve prospective memory during a computer task, which simulates a real life task.

What does taking part involve?

If you decide to take part you will be asked the following:

(1) To complete four short questionnaires and complete three short tasks. The information from these will help us find out more about the current difficulties you experience in everyday life.

(2) Next, complete a Removals Task which is done on a computer and will involve you taking on the role of a removal person. The task simulates the task of packing up a house for moving to a new house.

(3) About 10-14 days later we will ask you to come back to the Community Treatment Centre to carry out a slightly different version of the Removals Task

Does the research involve any medical examination or medication?
No.

What happens to the information?

The information from your test scores and the Removals Task are kept in strict confidence within the study team. The data are held in accordance with the Data Protection Act which means that we keep it safely and cannot reveal it to other people – even the clinical team – without your permission.

If we publish any findings from the study, this will be in the form where your results are combined with those of many other people and *average* scores are presented. We take very special care not to publish any details that could lead an individual to be identified. If you would like to see an example of the form in which results are published, please just ask a member of the study team.

If I don't want to take part?

Whether or not to take part is entirely up to you. Whilst our research relies on the help of volunteers we quite understand that there may be many reasons not to take part. You do not need to give a reason and we completely respect that decision. This project is completely separate from any clinical services you may be receiving and your decision has no effect on your access to these services.

If I agree to take part and then change my mind?

You can withdraw from the study at any stage without having to give a reason.

Will taking part have any advantages for me – will it improve my prospective memory?

Our research is entirely experimental. Our aim is to improve understanding and assessment and to *explore* strategies that *may* be useful. It is safest to assume that taking part will have no effect on your ability to remember to do things. If you do find the prompting strategy useful, if you give us your permission, we will discuss this with the clinical team to identify if there are ways this information may help in your rehabilitation programme and in your everyday life.

Who is funding the research?

This research is being funded by the University of Glasgow

Who has reviewed the study?

This study has been reviewed by the NHS Greater Glasgow Primary Care Division Local Research Ethics Committee.

If I have any further questions?

We will give you a copy of this information sheet and the signed consent form to keep, but if you would like more information before you decide whether or not to take part, please ask a member of the project team.

Who should I contact?

The project team are;

Pamela Brown, Trainee Clinical Psychologist, Section of Psychological Medicine, Gartnavel Royal Hospital, 1055 Great Western Road, Glasgow, G21 OXH. 0141 211 3978; mobile: 07722057723; pambrown08@yahoo.co.uk

Professor Jonathan Evans, Professor of Applied Neuropsychology, Section of Psychological Medicine, Gartnavel Royal Hospital, 1055 Great Western Road,Glasgow, G21 0XH. 01412113978; jonathan.evans@clinmed.gla.ac.uk

Dr Siobhan Sweeney, Clinical Psychologist, Community Treatment Centre for Brain Injury, 70 Commercial Road, Gorbals, Glasgow, G5 0QZ. 0141 300 6313.

If I have a complaint about any aspect of the project?

If you are unhappy with any aspect of your participation in the project, please first contact Pamela Brown, who is the principal investigator for the project. Should any complaint not be resolved satisfactorily, you can contact Mr Brian Rae, Research Manager for NHS Greater Glasgow Primary Care Division (R&D Directorate, The Tennant Institute, Western Infirmary, 38 Church Street, Glasgow, G11 6NT, 0141 211 0284 brian.rae@ggc.scot.nhs.uk).

Prospective Memory Study

Name ……………………………………………………………………

Telephone Number ………………………………………………………...

Address …………………………………………………………………….

Please tick:

☐ I would like to participate in this study/ would like more information on this study.

Please return this reply slip in the freepost envelope provided.

Appendix 2.9 **Participant consent form (brain-injury group)**

Acute Division
Rehabilitation and Assessment Directorate

NHS
Greater Glasgow and Clyde

UNIVERSITY of GLASGOW

Section of Psychological Medicine, University of Glasgow
Community Treatment Centre for Brain injury, Glasgow

Consent Form

Study Title: The effects of utilising periodic alerts and goal management training to improve prospective remembering on a virtual reality task.

Please initial box

I confirm that I have read and understand the information sheet dated 02/01/09 (version 2) for the above study and have had the opportunity to ask questions. ☐

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected. ☐

I understand that sections of my medical notes may be looked at by the research team where it is relevant to my taking part in the research. I give permission for the research team to have access to my records. ☐

I give my permission for my GP to be informed that I am taking part in this study. ☐

I agree to take part in the above named study ☐

________________________ __________ __________________

Name of participant Date Signature
.

____________________ _____ __________ __________________

Name of researcher Date Signature

Appendix 2.10 **Participant reminder leaflet (brain-injury group)**

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Acute Division
Rehabilitation and Assessment Directorate

NHS Greater Glasgow and Clyde

UNIVERSITY of GLASGOW

Section of Psychological Medicine, University of Glasgow
Community Treatment Centre for Brain injury, Glasgow

Prospective Memory Study

Dear ………………

You recently received information on a research project being conducted jointly by the Community Treatment Centre for Brain Injury and University of Glasgow. This is a quick reminder to see if you are interested in participating in this study. If you would like to participate, or would like more information on the study you can discuss this with a member of the clinical team at your next appointment. Alternatively, you can contact Pamela Brown on 07722057723, or e-mail: pambrown08@yahoo.co.uk for more information.

Remember, this study is voluntary; you are not obliged to take part and if you feel you would rather not, this will not affect your clinical treatment in any way. Even if you agree to take part, you are completely free to withdraw from the project at any time without needing to give us a reason.

Yours Sincerely,

Denyse Kersel	Professor Jonathan Evans	Pamela Brown
Clinical Director	Consultant Clinical Psychologist	Trainee Clinical Psychologist

Appendix 2.11 Research & Development and Ethics Committee approval letters

Primary Care Division

Research & Development Directorate
NHS Greater Glasgow and Clyde
The Tennent Institute
WIG, 38 Church Street
Glasgow
G11 6NT

NHS
Greater Glasgow and Clyde

Ms Pamela Brown
Trainee Clinical Psychologist
NHS Greater Glasgow and Clyde
Department of Psychological Medicine
Gartnavel Royal Hospital
Glasgow
G12 0XH

Date 18 November 2008
Your Ref
Our Ref BR/EC/approve

Direct Line 0141 211 8551
Fax 0141 211 2811
Email: emma.cuthbertson@ggc.scot.nhs.uk

Dear Ms Brown,

Reference Number: **PN08CP449**
Project Title: **Improving planning and prospective memory in a virtual reality setting: Investigating the use of periodic auditory alerts in conjunction with goal management with acquired brain injury.**

Thank you for submitting a Research & Development (R&D) Management Approval Application for the above study. I am pleased to inform you that R&D management approval has been granted by NHS Greater Glasgow & Clyde Community & Mental Health Partnership subject to the following requirements:

- You should notify me of any changes to the original submission and send regular, brief, interim reports including recruitment numbers where applicable. **You must also notify me of any changes to the original research staff and send CVs of any new researchers.**
- **Researchers covered by this approval are:- Ms Pamela Brown, Professor Jonathan Evans, Dr Siobhan Manuell.**
- Your research must be conducted in accordance with the National Research Governance standards. (see CSO website: www.show.scot.nhs.uk/cso)
- Local Research Governance monitoring requirements are presently being developed. This may involve audit of your research at some time in the future.
- You must comply with any regulations regarding data handling (Data Protection Act).
- A final report, with an abstract which can be disseminated widely within the NHS, should be submitted when the project has been completed.

Do not hesitate to contact the R & D office if you need any assistance.

Thank you again for your co-operation.

Yours sincerely

Brian Rae
Research Manager

Primary Care Division

NHS
Greater Glasgow and Clyde

Research Ethics
R&D Directorate
1st Floor – The Tennent Institute
Western Infirmary
38 Church Street
Glasgow G11 6NT
www.nhsggc.org.uk

Ms Pamela Brown
Trainee Clinical Psychologist
NHS Greater Glasgow & Clyde
Department of Psychological Medicine
Gartnavel Royal Hospital
Glasgow
G12 0XH

Date 29 October 2008
Your Ref
Our Ref
Direct line 0141 211 2123
Fax 0141 211 2811
E-mail Liz.Jamieson@ggc.scot.nhs.uk

Dear Ms Brown

Full title of study: **Improving planning and prospective memory in a virtual reality setting: Investigating the use of periodic auditory alerts in conjunction with goal management training on a complex virtual reality task in individuals with acquired brain injury.**

REC reference number: **08/S0701/102**

Thank you for your letter of 10 October 2008, responding to the Committee's request for further information on the above research.

The further information was considered at the meeting of the Committee held on 23 October 2008. A list of the members who were present at the meeting is attached.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

The favourable opinion applies to the research sites listed on the attached form.

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission at NHS sites ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Website > After Review

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

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

- Notifying substantial amendments
- Progress and safety reports
- Notifying the end of the study

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

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

08/S0701/102	**Please quote this number on all correspondence**

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

Yours sincerely

W.T. McCartney

pp **Liz Jamieson, Research Ethics Co-ordinator ~~on behalf of~~**
Dr Paul Fleming
Chair

Enclosures: *List of names and professions of members who were present at the meeting and those who submitted written comments.*
"After ethical review – guidance for researchers"
Site approval form

Copy to: *R&D office for NHS care organisation at lead site*

APPENDIX 3.1: Major Research Proposal

Improving planning and prospective memory in a virtual reality setting: Investigating the use of periodic auditory alerts in conjunction with goal management training on a complex virtual reality task in individuals with acquired brain injury

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Abstract

Deficits in planning and prospective memory are common after brain injury and contribute to difficulties participating in everyday activities. Recent research has suggested that using non-contingent auditory alerts may facilitate a 'goal-review' process and improve performance on tasks that make demands on executive functions. Although initial studies have been promising, if this intervention is to be clinically useful, its effectiveness in complex everyday environments must be demonstrated. Virtual reality environments offer the opportunity to evaluate interventions in situations that mimic complex real-world situations, whilst retaining experimental control. The proposed study will examine whether an intervention that combines periodic alerts with a brief goal-management training programme will improve performance of people with acquired brain injury on a complex, virtual-reality task that makes demands on planning and prospective memory skills.

Introduction

Executive functioning is the term used to describe a range of higher-level cognitive processes necessary for successful planning, reasoning, and the control of attention. McDonald and colleagues (2002) report executive dysfunction as a common and disabling aspect of cognitive impairment following acquired brain injury. One function that is vulnerable to the effects of executive dysfunction is prospective memory (PM; realising delayed intentions), as PM makes demands on memory, attention and executive systems (Fish et al., 2007).

In recent years, a number of studies have suggested that external alerting may be an effective prospective memory rehabilitation technique. Evans and colleagues (1998) used an automated paging system (NeuroPage) for an individual with relatively preserved memory functioning who showed a discrepancy between stated intention and the ability to act on these intentions. The intervention was effective in facilitating intended action, the pager alerts apparently acting as an "external executive system", compensating for an impaired frontal-lobe supervisory attentional system.

Subsequently, Manly and colleagues (2002), found a significant improvement in the performance of a group of brain-injured participants completing a multi-element task (the Hotel Task) when participants were provided with non-contingent auditory alerts (random 'beeps'). Whilst the Hotel task was considered by Burgess et al. (2006) to be more ecologically valid than most traditional tests of executive function[5], nevertheless it is important that the usefulness of auditory alerts is examined in situations that reflect more closely the demands of everyday activities. To this end, Fish et al. (2007) found that alerts (delivered via Short Message Service texts) improved the ability of brain-injured participants to remember to make telephone calls at specified times of the day over a two-

[5] These authors have argued that the Hotel Test has greater ecological validity than traditional tests such as the Wisconsin Card Sorting Test (WCST), and Morris et al. (2002a) have reported studies where classical "frontal" tests have failed to distinguish individuals with executive dysfunction from healthy controls, yet these individuals may exhibit severe functional impairment in daily life (Eslinger & Damasio, 1985).

week period. In addition to text-alerts, participants in Fish et al.'s (2007) study also received goal management training (GMT), a cognitive training programme that aims to improve goal-directed behaviour by instructing individuals to review intended goals and current actions (Levine et al., 2000).

Another approach to testing interventions in ecologically relevant situations, whilst retaining experimental control, is to use virtual reality environments (Morris et al., 2002b). Morris and colleagues (2002a) developed the virtual 'Removals Task', a novel procedure designed to mimic a complex real-world situation, which assesses strategy formation, rule-breaking and prospective memory. Sweeney et al. (2007) tested whether auditory alerts would improve performance on this task, but found no effect of alerting in a group of people with executive dysfunction. They hypothesised that, on more complex (ecologically realistic) tasks, a more extensive goal management training, similar to that used by Fish et al. (2007), may be needed in order for people with brain injury to benefit from the use of auditory cueing. The aim of the present study is, therefore, to test the hypothesis that an intervention combining GMT with periodic alerts will improve the performance of people with acquired brain injury in a complex, virtual-reality task that makes demands on planning and prospective memory.

AIMS

1. To compare performance of individuals with executive dysfunction and healthy controls on the Removals Task.
2. To compare performance on the Removals Task in individuals with executive dysfunction receiving GMT/auditory cues versus no GMT/auditory cues.
3. Using data from Sweeney et al.'s study (2007), the performance of participants who completed the Removals Task with auditory alerts and no GMT will be compared with that of participants in the current study who complete the task with auditory alerts and GMT.

Hypotheses

1. Individuals with executive dysfunction completing the task without GMT/auditory alerts will be impaired compared to healthy controls.
2. The executive dysfunction group will show improvement in the GMT/auditory cues condition compared to when completing the task with no GMT/auditory alerts.
3. Individuals will show improved performance in the GMT/auditory cues condition compared to participants in Sweeney et al.'s study, who received auditory alerts with no GMT.

Plan of Investigation

Participants

Nineteen participants will be recruited to each group (experimental and control).

Experimental Group:

Inclusion criteria: 18-65 year olds with evidence of executive impairment caused by acquired brain injury. Initial recruitment will be on basis of clinician's judgement with further testing for evidence of executive dysfunction then being conducted.

Exclusion criteria: Individuals with learning disability, and those with executive dysfunction as a result of neurodegenerative conditions such as dementia. Exclusion criteria will also apply to those with a history of aggression, severe perceptual problems, severe dysphasia (which may affect ability to understand test instructions) and severe mental illness (e.g. psychosis), which in the judgement of the clinical team and/ or experimenter would prevent effective participation in the study.

Control group:

Participants must have no previous history of neurological illness or head injury resulting in loss of consciousness, and will be age, sex, and IQ matched as much as possible with the experimental group.

If the situation arises where the main researcher is unable to recruit the specified number of control participants to the current study, control group data will be used from Sweeney et al.'s (2007) study, though participant characteristics (age, sex and IQ) will be compared to ensure they are well-matched. Experimental group data will be used from Sweeney et al.'s study (2007) for individuals with executive dysfunction who completed the Removals Task with auditory alerts and no GMT.

Recruitment

Participants will be recruited from Headway organisations in Glasgow, Lanarkshire and Greenock, as well as the Community Treatment Centre for Brain Injury (CTCBI) and Momentum. Relatives and friends of individuals with acquired brain injury will be invited to participate in the control group.

Measures

Pre-experimental measures:

To examine the level of executive impairment, the experimental group will complete the DEX questionnaire and Modified Six Elements test from the Behavioural Assessment of

Dysexecutive Syndrome (BADS, Wilson et al., 1996). The Logical Memory subtest from the Wechsler Memory Scale – 3rd Edition (WMS-III) and Rey Complex Figure Test (RCFT) will be used as measures of immediate and delayed verbal and visual recall, respectively. The prospective and retrospective memory questionnaire will also be completed (and where possible relatives will be asked to complete a proxy version) to investigate how prospective memory failures impact on their everyday lives.

Both control and experimental groups will complete the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) as a measure of current and pre-morbid IQ, respectively.

Experimental measures:

In the virtual Removals Task (Morris et al., 2002a), the participant is told that they are a removal person instructed to move furniture and items for owners moving to a new house, they must navigate through a storage unit, entering various rooms with different items of furniture in each. A **strategy** score can then be calculated for each participant looking at the efficiency of their strategy for collecting furniture.

There are a number of tests of prospective memory embedded in the Removals Task:

Activity-related: remembering to shut front door and room doors each time they exit.
Time-related: number of times participant visited front door and at what times.
Event-related: number of times they correctly label items as fragile and leave them in the room.

Design

This investigation will use a mixed design and groups will be partially randomised. There are two testing conditions:

Completing the Removals Task -

1. With no GMT/alerts.
2. With GMT/alerts.

Research Procedures

The Removals Task is delivered via laptop computer. There are a number of instructions participants must follow (see Appendix 2.4):

1. Furniture must be collected in a specific order.
2. Fragile items must be labelled.
3. Certain doors closed.
4. Front door visited at certain times.

Rule 1 is used to elicit rule breaking and strategy formation, while rules 2-4 are designed to investigate event-, activity- and time-based prospective memory (Morris et al., 2002b).

Task instructions will be encoded using errorless learning and provided on a summary cue card next to the computer, to ensure that as far as possible, errors/omissions will be due to errors in the task's executive demands, rather than its mnemonic demands. The GMT procedure used in this study (Appendix 3.2) is a brief version adapted from Robertson et al.'s (personal communication) GMT handbook for use by Fish et al. (2007). In the alerts condition, tones will be delivered using a CD player, semi-randomly, ensuring that tones do not coincide with times to check the front door. Testing conditions and both versions of the Removals Task (used to minimise practice effects) will be counterbalanced.

The Control group will complete the Task once, with no GMT/alerts, as Manly et al. (2002) have described piloting which suggests that control performance would be too close to ceiling to allow useful investigation of the experimental condition. The experimental group will be re-tested after 1 week. To improve retention, participants will receive a reminder phone call about the second appointment. Individuals with executive dysfunction will undergo no more than 3 hours of testing, while controls will undergo 1.5 hours testing.

Justification of Sample Size

Manly et al. (2002) show a large effect size (ES calculated to be 1.02 using pooled standard deviation) using auditory alerts on the Hotel Task, a task considered to have similar cognitive demands to the Removals Task (though completed in a shorter time period). Sweeney et al.'s study (2007) found a small-medium effect size (ES calculated to be 0.25) using alerts in the Removals Task, however, Fish et al. (2007) reported a medium-to-large effect size (ES reported as $F_2 = 0.269$, using Cohen's 1992 guidelines) using a different prospective memory task when combining auditory cueing and GMT, and this effect prevailed over a two-week period. Therefore, there is justification for assuming that auditory alerts, in conjunction with GMT, will provide a medium-large effect size in the current study.

Using a one-tailed matched pairs t-test on the statistical programme G*Power (Faul et al., 2007) to compare executive dysfunction group means on the Task with GMT and alerts, versus without GMT or alerts, based on an estimated medium-large effect size (0.6), with alpha error at 0.05 and power at 0.8., it is predicted that 19 participants will be required.

Settings and Equipment

Setting:

Testing will be conducted at the Community Treatment Centre for Brain Injury, Momentum and Headway organisations in Glasgow, Lanarkshire and Greenock.

Equipment:

The Removals Task will be delivered via laptop computer and alerts via CD player. GMT will be administered using the GMT manual adapted from the Fish et al. (2007) study.

Data Analysis

Both parametric and non-parametric statistics will be used, as the strategy measure uses ordinal data, while the prospective memory tasks use interval scores.

Demographics analysis

Unrelated t-tests and chi-squares will be used to compare the following groups on measures of IQ, age and sex:

1. Control and experimental group.
2. Experimental group and Sweeney et al.'s experimental group (level of executive dysfunction between groups will also be compared using these statistics).
3. Current control participants and Sweeney et al's control participants.

Within-groups analysis:

Comparing individuals with executive dysfunction performance with GMT/auditory alerts (AA) versus without GMT/AA:

1. Wilcoxon Signed Rank test to compare strategy scores.
2. A 2x3 Repeated Measures ANOVA to compare performance on the time, event and activity-based prospective memory tasks. Post-hoc comparisons using Scheffe Test or multiple comparisons t-test.

Between-groups analysis:

Comparison of control and experimental group under standard, non-alerted condition:

1. Mann-Whitney U tests to compare rule break and strategy scores.
2. 2x3 Mixed ANOVA to compare performance on prospective memory tasks; with one between-group variable (brain-injured versus neurologically intact) and three-within groups measures (time, event and activity-based prospective memory scores). Post-hoc comparisons using Scheffe Test or multiple comparisons t-test.

Comparison of brain-injured group in AA/GMT condition and Sweeney et al group's AA and No GMT condition:

1. Mann-Whitney U tests to compare rule break and strategy scores.
2. 2x3 Mixed ANOVA to compare performance on prospective memory tasks. Post-hoc comparisons using Scheffe Test or multiple comparisons t-test.

Health and Safety Issues

Researcher Safety Issues:

Research will be conducted within clinical settings in normal working hours, and the field supervisor will be informed of all arranged testing sessions.

Participant Safety Issues:

Testing will be conducted in a safe environment under the supervision of the main researcher.

Ethical Issues

Ethical approval will be sought from the Greater Glasgow Primary Care Ethics Committee.

Signed informed consent will be sought before testing, and only those considered to have capacity to consent will be approached. Individuals will be reassured that abstaining from participating will not affect their clinical treatment. To ensure confidentiality, personal information will be coded, removing identifiers, and stored securely in a locked cabinet. Computer data will be kept in password-protected files. In preparation for the unlikely disclosure of self-harm, participants will be informed before testing of the researcher's duty of care meaning that concerning information would supersede any confidentiality rights and details would be passed to the field supervisor and clinical team involved with this individual.

Financial Issues

It is estimated that overall costs; including reimbursed travelling expenses, experimental score-sheets, questionnaires, and administration costs, will equal £324.58 (see Appendix 3.3 for breakdown of costs).

Timetable

May 2008 – June 2009 (see Appendix 3.4 for timescale).

Practical Applications

Permission will be sought from participants who demonstrate improvements with auditory alerts/GMT to notify the clinical team so that they can consider the implementation of such measures as part of their rehabilitation programme.

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Appendix 3.2 Details of goal management training procedure[6]

The main researcher will go through goal management procedures with the experimental group participants individually. This will involve:

1. Describing the nature of prospective memory, and looking for any examples the participant can think of in their everyday life.
2. Linking these PM failures with "running on autopilot" and describing how we can use the "mental blackboard" as a way of moving out of autopilot, by using the catchphrase STOP (Stop, Think, Organise, and Plan).
3. Applying strategies like STOP to help improve prospective memory in everyday life.

[6] GMT procedure will replicate that of Fish et al. (2007), who used an abbreviated version from Robertson, I.H., Levine, B. & Manly, T. (personal communication). *The Goal Management Training Handbook.*

** Because half the experimental group will undertake the GMT/alerts condition first and then complete the no GMT/alerts condition second, in order to ensure that participants do not have visual reminders of using GMT, all of the experimental group will receive the GMT training booklet at the end of the second session.*

Appendix 3.3 **Study Costs**

Costing*:

WTAR score-sheets x 38 (2xPack of 25) = £78.00
Dysexecutive Questionnaire x 19 (1xPack of 25) = £28.00
Retrospective & Prospective Memory questionnaires (& Carers questionnaire). Free to photocopy x 38 (38 x £0.03) = £1.14
BADS Record Form - Six Elements: can use own score-sheet = 0
Experimental Measures Total = £107.14

** Prices from www.pearson-uk.com*

50 Information Packs:
Photocopying - approximately 5 sheets in each pack (250 x £0.03) = £7.50
50 A4 envelopes (1 box of 250) = £4.09
1 ream (500 sheets) white paper = £1.85
50 sheets headed paper (at £0.16 each) = £8.00

Postage (Freepost = 25p per letter) x 100 (50 information packs with 50 Freepost mail replies) = £25
Administration Costs Total = £46.44

Travelling Expenses:
Assuming return bus journey costs £3.00
Control group (one return bus journey x 19) = £57.00
Experimental group (two return journeys x 19) = £114.00
Travelling Expenses Total = £171.00*

** This is assuming all participants travel by bus and claim travel expenses. However, previous studies show that some participants use their own transport and not all will claim expenses, therefore actual total cost may average half the sum given above.*

Total Cost Overall = £324.58

Appendix 3.4 Research Timescale

April 2008:	MRP Research Agreement, Health & Safety form, Costing form, Start logbook.
May – September 2008:	Ethics approval, Research & Development Approval, Ordering test materials and administration supplies.
October 2008:	Research Progress Meeting.
October – December 2008:	Begin Data Collection.
January – March 2009:	Complete Data Collection and 2nd Research Progress Meeting.
April - May 2009:	Complete Data Analyses and submit drafts to supervisor. 3rd Research Progress Meeting.

June 2009:	Complete final draft.
July 2009:	Loose bind and submit.