FACTORS AFFECTING RESPONSIVENESS TO TEACHING STRATEGIES IN THE REHABILITATION OF ACQUIRED MEMORY IMPAIRMENT

VOLUME 1

RESEARCH COMPONENT

BY

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OVERVIEW

This thesis is submitted in partial fulfilment of the requirements for the degree of Clinical Psychology Doctorate (Clin.Psy.D) at the University of Birmingham. It comprises a research component (Volume I) and five clinical practice reports (Volume II).

Volume I (research component) contains two papers. The first paper is a review of the literature, which examines the extent to which specific cognitive impairments should be taken into account when planning memory rehabilitation interventions based on teaching strategies such as cueing and errorless learning. The second paper is an empirical study which compares the effectiveness of implicit and explicit teaching instructions when using the method of vanishing cues to facilitate learning in people with memory impairment arising from acquired brain injuries. Both papers have been prepared for submission to Neuropsychological Rehabilitation (see Appendix I for submission guidelines).

Volume II comprises five clinical practice reports presenting work undertaken in the specialties of mental health (adult and older adult), learning disabilities and neurorehabilitation. The first presents an initial assessment of a 71 year old woman with generalised anxiety alongside formulations of her difficulties from cognitive-behavioural and psychodynamic perspectives. The second report contains a single case experimental design to evaluate the effectiveness of a cognitive rehabilitation intervention in an 81 year old man with Alzheimer's disease. The third report is a service evaluation addressing the needs of psychological therapists working with adults with Asperger's Syndrome/High Functioning Autism. The fourth report is a case study relating to a 66 year old man with a learning disability and challenging behaviour. An abstract for the fifth report is included, which presented a case study (assessment, formulation and intervention) of a 52 year old woman with Multiple Sclerosis and generalised anxiety.

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Finally, a special note of thanks goes to my family; my children Ella and Finley and above all to my wife Helen for her support, patience and understanding throughout the process of completing my thesis.

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LITERATURE REVIEW

TO WHAT EXTENT SHOULD IMPAIRMENTS OF EXECUTIVE FUNCTIONING AND SEVERITY OF EXISTING MEMORY IMPAIRMENTS BE TAKEN INTO ACCOUNT WHEN CONSIDERING PEOPLE FOR ERRORLESS LEARNING AND OTHER TEACHING BASED MEMORY REHABILITATION APPROACHES?

ABSTRACT

A range of teaching strategies are used in the rehabilitation of memory impairment. However, the literature says little about the factors influencing their effectiveness. This literature review aimed to identify whether two main aspects of cognitive functioning, executive functioning difficulties and existing memory impairment (and severity thereof) impact on the use of these strategies.

Fifteen studies were reviewed in relation to these issues. Most of these studies did not address the issues as a major aim. It was concluded that although there is an emerging view that executive functioning difficulties can adversely impact on the benefit gained from using these strategies, this requires greater support from methodologically robust empirical studies. A further predictable conclusion from the studies reviewed was that people with more severe memory impairments learn less well than the less severely impaired. A general rule appears to be emerging favouring effortful approaches (that may carry an increased risk of errors) for those with less severe impairments, and approaches that focus on constraining errors for those with more severe memory impairments. Again this requires more extensive investigation. Improved clarity around the measurement and definition of impairment severity is required. The clinical implications of these findings and possible directions for future research are discussed.

INTRODUCTION

Psychological approaches to the remediation of cognitive deficits caused by brain damage and disease draw on understandings from (inter alia) neuropsychology, cognitive psychology and behavioural psychology (Prigitano, 1999). One particular area that has received increasing attention during the last two decades is the use of teaching strategies based on principles of behaviour modification, such as cueing procedures (e.g. Glisky, Schacter & Tulving, 1986), errorless learning (Baddeley & Wilson, 1994) and retrieval practice (Camp, 1989). Their origins lie in the behavioural studies of animal learning and the practical application of the behavioural findings in the learning disability field (Sidman & Stodart, 1963), as well as in education generally (e.g. Skinner's teaching machines (Skinner, 1968)).

The main aim of errorless learning is preventing people from making mistakes in new learning situations. Following Baddeley and Wilson (1994), this principle has been widely adopted in memory rehabilitation work. An arguably contradictory but widely applied principle is that of 'effortful processing' (Komatsu, Mimura, Kato, Wakamatsu & Kashima, 2000), which suggests that factors such as depth of processing and cognitive effort affect the chances of success in new learning situations. Either/both principles can be used independently or combined with specific teaching strategies. Cueing is a strategy which involves the provision of a hierarchy of retrieval prompts to the learner. There are various ways in which cues can be faded, with variable factors including the direction of the assistance and the speed of fading (Riley & Heaton, 2000). One commonly used application is the method of vanishing cues (MVC; Glisky et al., 1986). Somewhat confusingly their original application of this approach actually involved the provision of increasing assistance on the first teaching trial, albeit more recently this approach has been associated with decreasing assistance on all trials, and the gradual fading of cues/prompts to enable stimulus control to be transferred to the naturally occurring antecedents for the response (Skinner, 1968). Some teaching strategies do not involve cueing, for example retrieval practice. This too can be applied in a variety of ways (e.g. Hochhalter, Overmier, Gasper, Bakke, & Holub, 2005). Spaced retrieval involves presentation of the material to be learned followed by immediate testing and thereafter further testing with gradual increases in the interval period of retention. Both spaced retrieval and the MVC are regularly combined with errorless learning principles in clinical practice.

These approaches have been used to address a range of cognitive difficulties (e.g. memory and language), and many studies have evidenced their effectiveness. However, there are some methodological limitations with these studies (Bier et al., 2008). For example, they do not always employ control conditions to confirm the efficacy of the interventions tested, and although some neuropsychological assessment data are usually presented, this varies considerably across studies, and few link performance on standardised measures to described levels of memory impairment (Ehlhardt et al., 2008). Indeed, the literature says little about the factors that may influence whether or not such interventions will be effective and particularly whether there are aspects of participants' cognitive profiles resulting from their brain injury or disease that may impact on their responsiveness to these various teaching strategies. This prompts consideration of two main questions:

1. Is the effectiveness of these different teaching strategies affected in general terms by the presence of these cognitive impairments? For example, are people with executive functioning difficulties less likely to benefit from specific teaching strategies than those with intact

executive functioning? Answering such questions should provide general guidance to clinicians with regard to candidacy for memory rehabilitation interventions.

2. Do such cognitive impairments have a differential influence on the effectiveness of the different teaching strategies? In other words, might one particular strategy be more effective than another strategy for people with a particular profile of neuropsychological impairments, whilst the reverse applies for people with a different profile? Answering these questions is arguably of greater interest as this would help guide clinicians in relation to which particular teaching strategy is more or less likely to work with each particular individual.

Aim of review

Whilst the primary aim of existing studies has rarely been to address the relationship between participants' cognitive profiles and their responsiveness to teaching-based interventions, this issue has been addressed in certain studies. Preliminary review of this literature suggests two aspects of participants' cognitive profiles have been given particular consideration; executive functioning difficulties and existing memory impairment (and severity thereof). Whilst the interaction of such difficulties may also affect responsiveness to teaching strategies at an individual level, this review is therefore structured around these two aspects in asking:

- To what extent should impairments of executive function be taken into account when considering people for errorless learning and other teaching-based interventions?
- What consideration should be given to severity of existing memory impairments when considering people for errorless learning and other teaching-based interventions?

Search strategy and inclusion criteria

Search criteria were generated by reference to the key concepts relevant to this review. Some papers included in the review were already known to the author, and reference was made to their keyword sections when generating search terms. Studies were identified by searching the PsycINFO database (1987 to February 2011). A keyword search was conducted using the terms "learning strategies", "mnemonic learning", "trial and error learning", "memory training", "cued recall", "memory disorders", "cognitive impairment" and "cognitive ability". This strategy yielded 318 items of which 306 were disregarded either because the abstract contained nothing of relevance to this review or because they were book chapters or theoretical articles which did not report empirical data. This left 12 items, and after brief review, a further six were discarded due either to the absence of a clearly defined teaching based intervention and/or insufficient information regarding participants' neuropsychological profiles and their relationship to outcome. A further nine items were identified through hand searching the reference lists of the six remaining articles (i.e. studies cited within a relevant reference), yielding a total of 15 articles for inclusion in this review.

As reported above, many papers were excluded due to the lack of relevant information in the abstract. It is recognised that it is possible they may contain information relevant to this review, but that the authors felt that this material was not of sufficient interest to include in the abstract. In any event, time constraints prevented detailed review of all the items identified in the initial search.

The 15 studies included in this review are listed at Table 1. Each met the following inclusion criteria. Each used participants with either acquired (non-progressive) brain injury or neurodegenerative conditions with evidence of memory impairment. Each employed at least one behavioural teaching strategy to address memory impairment. Finally each reported participant neuropsychological assessment data (either at a group or individual level) which indicated impairments of memory and/or executive functioning and made some attempt to relate this data to teaching intervention outcome.

Appendix I – Summary of Studies Reviewed

STUDY	PARTICIPANTS	NO Ps	TASK	TEACHING STRATEGY	NEUROPSYCH TESTS	RESULTS REPORT	SUMMARY OF COGNITIVE IMPAIRMENT ISSUES
Baddeley & Wilson, 1994. When implicit learning fails: Amnesia and the problem of error elimination.	Mixed brain injury (young and old controls)	16e 16$_{y}$c 16$_{o}$c	Stem completion	Errorless Learning (EL) vs. Errorful Learning	RBMT WCST, Verbal fluency	Individual	Amnesic Ps categorised into one of three executive functioning groups (no, mild, dysexecutive) – all three groups showed similar EL advantage, but (unreported) dysexecutive group learned less well in both conditions)
Gade, 1994. Imagery as a mnemonic aid in amnesia patients: Effects of amnesia subtype and severity.	Mixed brain injury	35	Verbal paired associates	Imagery Experimenter generated Self-generated	NART, Verbal IQ, Separate paired assoc test, Warrington Recognition memory test, Bushke errors, Rey figure (delay)	Means per group (mild, moderate, severe)	All Ps benefited from imagery but most severely amnesic only minimal benefit – moderately impaired benefit but less so if self generated, mildly impaired benefit greatly - benefit maintained with self generation
Thoene & Glisky, 1995. Learning of face-name associations in memory-impaired patients: A comparison of different training procedures.	Mixed	12	Face name association	Mnemonic Vanishing cues (VC) Video	WAIS-R, WMS-R (MQ, verbal memory index), Rey Auditory Verbal Learning Test	Individual	Mnemonic effective for all participants VC/video less effective for severely impaired
Canellopoulou and Richardson, 1998 The role of executive function in imagery mnemonics: evidence from multiple sclerosis (MS)	MS	50	Verbal paired associates	Imagery mnemonics	Test of visual imagery control, Vividness of visual imagery questionnaire, Benton's verbal fluency, Cognitive estimation test, Modified card sorting test	Means only	Imagery mnemonics work but self generated less effective than experimenter generated. Executive processing capacity determines benefit gained from use of more complex forms of imagery mnemonic in verbal learning tasks

Table 1 – Summary of Studies Reviewed

STUDY/CLASS	PARTICIPANTS	NO Ps	TASK	TEACHING STRATEGY	NEUROPSYCH TESTS	RESULTS REPORT	SUMMARY OF COGNITIVE IMPAIRMENT ISSUES
Evans et al, 2000. A comparison of errorless and trial and error (T&E) learning methods for teaching individuals with acquired memory deficits – **Class III**	Mixed brain Injury	P1; 18 P2; 16 P3; 34	3 phases 9 tasks (names, routes etc)	T&E EL (EL+ chaining)	RBMT	Means only	More severely amnesic Ps benefit more from EL than less severe (but only if interval between learning and recall short)
Riley & Heaton 2000. Guidelines for the selection of a method for fading cues - **Class III**	Brain injury	12	General knowledge Questions	Cueing	NART, WMS-R Logical memory delayed, WAIS-R (Vocab, Comprehension, Similarities)	Yes individual	Increasing assistance better for more able and easier items Decreasing assistance more effective if poorer memory and items more difficult
Clare et al, 2002 Relearning face-name associations in early Alzheimer's disease (AD)- **Class III**	AD	12	Face name association	EL with mnemonic, VC and SR	NART, CPM, Graded naming test, RBMT, Doors and people, Visual Object and Space Perception Battery, WAIS-R (digit span), Test of Everyday Attention (Map 1&2, Elevator Counting with/without distraction), Stroop, Hayling, Brixton, BADS (zoo map, key search), Verbal fluency.	Individual	Commented no current score on any neuropsych measure appeared predictive of outcome. Visual inspection of data suggests people with greater impairments of executive functioning and more severe memory impairment may have learned less well
Tailby &Haslam, 2003 An investigation of EL in memory impaired patients - **Class III**	Varied (12 head injury, 6 hypoxia, 3 dementia, 1 encephalitis, 1 Parkinson's)	24e	Words	Errorless, Self generated errorless, errorful (standard)	NART, WAIS-R (Block design, Vocabulary) WMS-III (Verbal memory index)	Mean scores per group only	Self generated EL advantage for mild, moderate and severely impaired groups EL advantage most dramatic in severely impaired group

Table 1– Summary of Studies Reviewed

STUDY	PARTICIPANTS	NO Ps	TASK	TEACHING STRATEGY	NEUROPSYCH TESTS	RESULTS REPORT	SUMMARY OF COGNITIVE IMPAIRMENT ISSUES
Mettzler-Baddeley & Snowden 2005, Brief report: Errorless vs. errorful learning as a memory rehabilitation approach in AD - **Class III**	AD	4	Object naming Face name assoc	Errorless vs errorful	NART, MMSE, Graded naming test, Verbal Fluency, Rey Copy, Doors & People, Sussex Test of Remote Memory.	Individual	EL may be most beneficial for those with profound amnesia and in situations that make effortful processing difficult, but residual explicit memory capabilities may override EL benefits
Hochhalter et al, 2005. A comparison of spaced retrieval (SR) to other schedules of practice for people with dementia. **Class III**	AD	11	Verbal and non verbal learning	SR/other practice schedules	MMSE, WMS-R (digits forwards/backwards) Hopkins Verbal Learning Test (immediate, delayed and discrimination index)	Individual	Ps with higher scores on 1 part of HVLT more likely to show long term retention of pill names regardless of schedule of practice
Page et al, 2006. What is the locus of the Errorless Learning (EL) advantage? - **Class III**	Stable organic memory impairment	23e 20c	Words	Errorless -v- errorful learning	WMS-III (Story Recall), RBMT	NO	EL benefit for both moderate and severely impaired groups
Pitel et al, 2006 Two case studies in the application of EL techniques in memory impaired patients with additional executive deficits - **Class IV**	Traumatic brain injury	2	-Face name association learning -Program personal organiser	EL with VC	Mill Hill Scale Grober & Buschke's test, RBMT, Digit span, Hayling test, Verbal fluency, Trails, WCST	Yes	Severe executive problems may hamper EL memory rehabilitation Mild executive probs may not hamper EL memory rehabilitation

Appendix I – Summary of Studies Reviewed

STUDY	PARTICIPANTS	NO Ps	TASK	TEACHING STRATEGY	NEUROPSYCH TESTS	RESULTS REPORT	SUMMARY OF COGNITIVE IMPAIRMENT ISSUES
Bier et al, 2008. Face-name association learning in early AD; A comparison of learning methods and their underlying mechanisms – **Class III**	AD	15e 15c	Face name association learning	SR VC EL	Digit span, Block tapping, Letter-number sequencing, Selective cued reminding test Face recognition, Verbal fluency, Semantic association match task, Benton's face discrimination, Stroop, Trails, Process Dissociation Procedure,	Individual	No significant correlations between free recall and cognitive profile although best performers had better remaining episodic memory
Lloyd, Riley & Powell, 2009 EL of novel routes through a virtual town in people with acquired brain injury **Class III**	Miscellaneous brain injury (8 traumatic brain, 6 vascular, 6 other)	20	Virtual route learning	EL -v- Errorful learning	Adult Memory Information Processing Battery (List learning), Rey figure, immediate and delayed recall	Means by disorder	Small no of Ps who did not benefit from EL appeared to benefit from errors made in previous trials. This group appeared to have less severe memory impairments.
Mimura & Komatsu, 2010 Factors of error and effort in memory intervention for patients with Alzheimer's disease (AD) + amnesic syndrome (AS) **Class III**	AD-18 AS -12	30	Learning category examples	-VC -EL without fading -Category generation -Target selection	AD – MMSE, Alzheimer's Disease Adjustment Scale (Japanes version) - ADAS-J AS – MMSE, ADAS-J, WAIS-R, WMS-R (attention/ concentration index and delayed recall index)	Means only	EL benefit for both groups Effortful learning only beneficial for AS on free recall test AD deficit in effortful due to deficit in carrying out

Class according to American Academy of Neurology (AAN) classification system; e = experimental group; c = control group; RBMT = Rivermead Behavioural Memory Test; WCST = Wisconsin Card Sorting Test; NART = National Adult Reading Test; IQ = Intelligence Quotient; WAIS-R = Wechsler Adult Intelligence Scale, Revised Edition; WMS-R = Wechsler Memory Scale, Revised Edition; MQ = Memory Quotient; CPM = Raven's Coloured Progressive Matrices; BADS = Behavioural Assessment of Dysexecutive Syndrome; WMS-III = Wechsler Memory Scale, Third Edition; MMSE = Mini Mental State Examination.

To what extent should existing impairments of executive functioning be taken into account when considering people for errorless learning and other teaching-based interventions for memory problems?

The study of executive dysfunction is relatively new in relation to other areas of cognitive functioning, and there remains some debate in the neuropsychological literature with regard to the classification of executive functions, in particular as no single theory of impairment can account for the variety of dysfunctions associated with them (Stirling & Elliott, 2009). Nevertheless there is general agreement that executive dysfunction is wide ranging and often associated with significant levels of disability (Kennedy et al., 2008). As frontal executive systems are considered crucial for rehabilitation generally (Robertson & Murre, 1999), it might be hypothesised that executive dysfunction may impact negatively on teaching strategies commonly employed in the remediation of cognitive difficulties during the rehabilitation process. In recent practice guidelines relating to the instruction of people with neurogenic memory impairments, Ehlhardt et al. (2008) suggested that executive functioning might be one participant variable which needs to be taken into account when planning systematic teaching-based memory rehabilitation. It referred to evidence that people with executive functioning impairments may benefit less from an errorless learning paradigm (Clare, Wilson, Roth & Hodges, 2002) and the method of vanishing cues (Leng, Copello & Sayegh, 1991). In the former study, which is included in this review, there was no statistical analysis of the relationship between executive functioning assessment data and outcome. The latter study (Leng et al., 1991) was a case study relating to a single participant who performed normally on assessments of executive function. Its conclusions were based only on anecdotal comparison to another client with apparent executive dysfunction who did not benefit in the same way from this approach. This study was omitted from the present review as it did not include neuropsychological assessment data in relation to the additional client (referring only to its participant being “impaired” on tests of executive dysfunction).

Five studies were identified for inclusion in relation to the executive functioning issue. Of these, three (Bier et al., 2008; Pitel et al., 2006; Clare et al., 2002) both included individual executive functioning assessment data and attempted to draw conclusions about its relationship with the outcome of a teaching-based memory intervention. A fourth (Baddeley & Wilson, 1994) classified participants into groups (no/mild/marked dysexecutive problems) on the basis of assessment data, but did not report these data. The final study included in this review (Canellopoulou & Richardson, 1998) did not report individual assessment data (mean group data were provided), but did go on to relate these data to memory intervention outcome.

Several studies included in this review incorporated some assessment of executive functioning as part of their neuropsychological evaluation of participants. Only the five studies mentioned in the previous paragraph attempted to draw any conclusions based on these data. The assessments used were varied, however some commonalities were identified. Three studies used card sorting tests, including the Wisconsin Card Sorting Test (WCST; Grant and Berg, 1993), and all five used verbal fluency assessments, commonly used as one measure of executive functioning, although one (Bier et al., 2008), appeared to use this to assess language. As such, given the wide range of tests designed to assess executive functioning, there is at least some homogeneity within the assessment procedures employed in these studies.

In their seminal paper relating to the impact of errors on learning in amnesic participants, Baddeley and Wilson (1994) were the first to refer to the possible impact executive functioning impairments. They reasoned that when learning under errorful conditions, the more executively impaired participants might be particularly disrupted by previous errors due to their increased tendency to perseverate. The authors divided their amnesic sample of 16 into three groups with differing executive functioning ability based on their performance on the WCST, a measure of verbal fluency and their CT scans. They compared learning performance across these groups and concluded that the errorless learning advantage over trial and error learning was as marked in the most impaired ("dysexecutive") group as in the other groups. However, the performance of each group is displayed in a graph, and this clearly indicates that the overall learning of the dysexecutive group was much reduced in comparison to the other groups in both errorful and errorless conditions, despite comparable mean levels of memory impairment. However, the amnesic sample is small, no information is given in relation to other factors, such as levels of general cognitive function, which may have impacted on performance, and it is important to note that the impact of executive functioning on learning generally was beyond the scope of this study. A further criticism of this aspect of the study is that it is unclear how the CT scan evidence was used/combined with assessment data to allocate participants to each executive group. Nevertheless, the poor learning of the dysexecutive group in this study might be interpreted as tentative, albeit weak evidence that existing impairments of executive function should be taken into account when considering people for errorless learning and other teaching-based interventions.

Executive functioning difficulties are commonly associated with multiple sclerosis (Rao, 1986), and their impact on an imagery-based mnemonic intervention was investigated in an isolated study focusing on this population (Canellopoulou & Richardson, 1998). The authors initially suggested that this type of intervention relies on metacognitive ability and is likely to be disrupted in the event of executive functioning impairments. They enhanced the study's methodological robustness by demonstrating that the three tests used to measure what they termed “executive processing efficiency” represented the same underlying construct. The study used increasingly complex forms of imagery to assist in different verbal learning tasks. It was found on a measure of free recall that executive processing efficiency was significantly correlated with the benefit derived from experimenter-generated imagery, and although this construct was not significantly correlated with the benefit gained from self-generated imagery, those participants with higher executive processing efficiency showed less of a decline in performance in a follow-up test. It was therefore concluded that executive capacity can determine the potential benefit of imagery mnemonics in verbal-learning tasks. This study also benefitted from a relatively large sample (50), albeit using participants with multiple sclerosis only. Its results provided evidence that executive functioning impairments can impact adversely on performance in imagery-based memory rehabilitation, suggesting that people with such impairments may not benefit from such approaches in the same way as the executively unimpaired.

As reported, the Ehlhardt et al. (2008) review concluded that the study by Clare et al. (2002) demonstrated some evidence that people with executive functioning impairments may benefit less from an errorless learning paradigm. This study incorporated six assessments of executive functioning in its neuropsychological evaluation. Although the paper itself fails to examine these data in relation to outcome (the only relevant comment being that these scores did not appear to predict outcome) as the study’s main aim was to investigate the relationship between impairments in awareness and outcome, the reporting of individual assessment data enables some further consideration of this issue. In terms of learning, for seven participants this was described as considerable (and maintained), for three slight (two with some maintenance) whilst for two there was no learning. Inspection of the executive functioning assessment data reveals that the all but two of the good learners were impaired on at least one measure. One good learner was impaired on four measures and one on all six. However, the three worst learners demonstrated impairments on three or more measures, and a significant inverse relationship was identified between learning performance and behavioural problems (often associated with impairments of executive functioning). Furthermore, the experimental intervention was relatively complex in that it comprised use of mnemonics, vanishing cues and spaced retrieval, and this may have undermined the progress of those with greater impairments in executive functioning, for example due to the adverse impact of perseveration. In summary, however the conclusion of Ehlhardt et al. (2008) that this study demonstrated some evidence that people with executive functioning impairments may benefit less from an errorless learning paradigm is difficult to substantiate, as although data inspection suggests that some participants with greater impairments on measures of executive function learnt less well, a significant minority demonstrated considerable and maintained improvements. Statistical analysis of the relationship between learning and performance on various measures of executive functioning may have helped to clarify the nature of this relationship.

The study by Pitel et al. (2006), in which the authors, like Baddeley and Wilson (1994), note the potential impact of perseveration on error monitoring/correction, is the first identified to directly address the impact of executive dysfunction on memory rehabilitation. Two case studies are reported. One participant is described as having "moderate memory impairment and a severe dysexecutive syndrome" and the other severe memory impairment but only mild executive (inhibition) difficulties. Each was taught a semantic and a procedural task combining errorless learning vanishing cues. The 'dysexecutive' participant's knowledge improved from between 20 and 40 per cent to between 60 and 80 per cent on the semantic task, whilst the mildly executively impaired participant's knowledge improved from between

10 and 30 per cent to 100 per cent. Both participants' learning was sustained at follow-up assessment after one month. On the procedural learning task, the mildly impaired participant learned perfectly using this approach, however the more impaired participant's performance on the procedural learning task was highly inconsistent. A marked difference between each participant's performance is described, however it is clear that both participants learned both tasks (at least to some extent). The authors conclude that the presence of significant dysexecutive impairment is likely to have a major adverse influence on the errorless learning approach, whilst the approach does not appear to be compromised by inhibition deficits alone. Clearly, this study has methodological flaws, not least its failure to control for extraneous variables and the absence of statistical analysis, which significantly limit any generalisations that can be made from its results. Therefore, although this study does draw further attention to the issue in question, its conclusions are not substantiated, and little weight is added to the argument in relation to the potential impact of executive dysfunction on strategy-based memory rehabilitation.

In one of the few studies with a direct aim of looking for relationships between participants' cognitive functioning and their level of performance, Bier et al. (2008) examined 15 participants' face-name association learning across five learning methods (errorless learning, vanishing cues, spaced retrieval and two trial and error methods). The results incorporated case study analyses which, inter alia, compared the performance of their five best and worst learners across the five methods. One measure of participants' executive functioning was the Stroop Test (Golden, 1978). Although participants with greater inhibition deficits (as measured by Stroop interference score) performed better on a free recall test using vanishing cues than the other methods, suggesting that this strategy is preferable for those with inhibition deficits, there were no significant differences between the best and worst learners.

Although other measures of executive functioning were used, the case study analysis focused only on inhibition deficits, concluding as did Pitel et al. (2006) that inhibition deficits alone are unlikely to influence participants' learning performance. It should be noted, however, that by comparing the performance of the five best and five worst learners on each learning method, the authors were reducing further an already small sample, thus further compromising the statistical power of their results. Limited further conclusions can therefore be drawn from this study.

In conclusion therefore it is clear that the literature examining the relationship between impairments in executive functioning and outcomes in teaching-based memory rehabilitation interventions is in its infancy. This is partly attested to by the very fact that a significant proportion of this review which aims to address this issue has considered data at an individual level. The main reason for this is that for the most part answering this question has not been a primary aim of the studies reviewed, thus even when executive functioning assessment data is available, its relationship to outcome has not been statistically analysed. A starting point for further consideration of this question may therefore be for those authors (Clare et al., 2002; Evans et al., 2000) who have data available to carry out further statistical analysis.

In the studies reviewed, there are some suggestions that significant executive functioning difficulties may impact adversely on teaching-based memory interventions, whilst mild inhibition deficits alone will not. However, given their sparse nature and the methodologies of some of the studies making these claims, they may only be considered tentative at this stage. Only two studies reviewed (Baddeley & Wilson, 1994; Bier et al., 2008) directly compared two or more teaching strategies. However, Baddeley and Wilson (1994) compared errorless learning only to a trial and error strategy, and the study by Bier et al., (2008) suggested only that those with inhibition deficits may benefit more from vanishing cues than other strategies. Nothing further can therefore concluded in relation to whether executive functioning difficulties predict differential responsiveness to different teaching strategies.

Notwithstanding the tentative nature of the above conclusions that significant executive functioning difficulties may adversely impact on teaching based interventions for memory difficulties, this does coincide with the conclusions of recent studies (e.g. Fillingham, Sage & Lambon-Ralph, 2006; Lambon-Ralph, 2010) relating to the treatment of anomia. These studies directly address this question, concluding that executive functioning difficulties are crucially related to treatment outcome, with better outcomes for the less significantly impaired. Likewise, a general conclusion that people with executive functioning difficulties do not learn well is unsurprising given the relatively strong relationship reported between measures of memory and executive functioning (e.g. Wechsler, 1997). At present a link only exists between executive functioning and performance, but there is no evidence or unified theory in relation to the mechanisms underlying this link. At an individual level, the studies reviewed contain indications that some people with significant executive impairments can learn well. Given the prevalence of neurologically impaired people with impairments of both memory and executive functioning, further controlled and theoretically driven studies are required with sufficient numbers to detect reasonable effect sizes. These should directly investigate both the impact of executive functioning difficulties on strategy-based memory rehabilitation generally, the aspects of executive dysfunction which are most likely to impact, the mechanisms by which they impact and whether such difficulties differentially affect responsiveness to different teaching strategies.

To what extent should severity of existing memory impairment be taken into account when considering people for errorless learning and other teaching-based interventions for memory problems?

Many studies have demonstrated that participants with memory impairments arising from various aetiologies can benefit from teaching strategies, however there is evidence that this benefit varies not only across neurological populations but also severity of impairment (Ehlhardt et al., 2008). Most of these studies have provided neuropsychological assessment data in relation to participants' existing memory impairment and/or have divided participants into groups on this basis, even though they have rarely explicitly aimed to question the impact of impairment severity on candidacy for intervention. Ehlhardt et al. (2008) reviewed the use of teaching strategies with memory impaired populations in order to generate practice guidelines for clinicians working in this field. One conclusion was that the issue of the impact of severity of memory impairment remains open to interpretation. However, this question too was only addressed briefly in this review. The aim of this section of the present review is therefore to attempt to summarise the various arguments and findings with regard to the relationship between severity of memory impairments and responsiveness to teaching strategies and to generate some sense of coherency and consistency between them.

The first study to address this issue identified for this review related to the use of imagery mnemonics in verbal paired associate learning (Gade, 1994), albeit severity ratings in this study were based on participants' paired-associate learning ability only. The author attempted to explain some previously conflicting results in terms of amnesic participants' abilities and found that the benefit derived from imagery mnemonics varied according to amnesia severity, and for the most severely impaired participants this benefit was not clinically significant. It was also reported that although both mild and moderately impaired participants benefitted from experimenter-generated imagery, when using self-generated imagery the performance of the mildly impaired group was maintained whereas the moderately impaired group benefitted less than when using experimenter-generated imagery.

This study's main aim was to investigate paired-associate learning across amnesia of varying aetiologies, and little is said about the reasons for the differences identified in terms of severity of impairment. One possibility may be that the moderately and severely memory impaired participants also experienced executive dysfunction which impacted on their ability to effectively apply mnemonic strategies. However, participants' executive functioning was not assessed in this study. Thoene and Glisky (1995) compared using imagery mnemonics with the MVC and a video presentation method in face-name association learning. Their mnemonic strategy combined verbal and visual elements, whereas the Gade (1994) study comprised a visual aspect only. They found that almost all participants (including the more severely impaired) performed best in the mnemonic condition and that the more severely impaired participants were unable to learn all of the names in the other conditions. Their sample of twelve included three participants with a Wechsler Memory Scale-Revised (WMS-R; Wechsler, 1987) delayed recall index score of less than 50 who by any definition would be classified as at least severely impaired. Prima facie these results are not wholly consistent with those of Gade (1994) and previous studies which have found that visual imagery mnemonics benefit those with mild to moderate impairments. One possibility raised by the authors is that the use of both verbal and visual modalities may have facilitated a deeper level of processing. They also suggest that as the mnemonics used were experimenter-generated and participants received clear instruction in their application, this may have reduced the demands on their already limited cognitive capacity, facilitating increased benefit from this approach.

Riley and Heaton (2000) investigated the use of cueing applications in greater depth. They identified an advantage for gradual fading (using decreasing assistance) for the more severely impaired and for more rapid fading (using increasing assistance) for the less severely impaired. This advantage was also related to item difficulty. However, it is arguable whether all 12 participants could be classified as memory impaired, as four fell in the average/high average range (percentile rank, WMS-R, Logical Memory-Delayed Index). As such their conclusions might be reframed as applying respectively to those with no/very mild impairments and the more severely impaired. Either way, an advantage for gradually reducing cues is advocated for the more severely impaired. In the Thoene and Glisky (1995) study, although participants learned in the MVC condition this was less effective than the mnemonic condition. However, it should be noted that the cues on the first trial used were increasing rather than decreasing. In the context of Riley and Heaton's (2000) findings this, in conjunction with the likelihood that a greater number of errors would have been made, may account for their less good performance. Errors are considered detrimental to the learning process (Baddeley & Wilson, 1994), particularly as we shall see for those with more severe memory impairments (Metzler-Baddeley & Snowden, 2005). Comparisons between the samples used in the two studies (based on mean WMS-R performance) indicate that the participants in the Thoene and Glisky (1995) study were far more severely impaired.

The late 1990s witnessed the widespread adoption of errorless learning principles in memory rehabilitation interventions. In a three phase study comparing 'errorless' and 'trial and error' approaches, Evans et al. (2000) considered the severity of impairment issue in relation to name learning. They found the errorless learning advantage to be greater for the more severely impaired participants (defined by their screening score on the Rivermead Behavioural Memory Test (RBMT; Wilson, Cockburn & Baddeley, 1985)). This was interpreted as demonstrating support for the hypothesis that the more severe the impairment of explicit memory the more participants have to rely on implicit memory, and if the errorless learning advantage arises from the reduction of interference with implicit memory then in situations where implicit retrieval can be relied on, the more severe the explicit memory impairment, the greater the gain provided by errorless techniques. Of note, however, was that this advantage disappeared after a delay suggesting that some implicit memory effects may be short-lived.

Linda Clare and colleagues (e.g. Clare et al., 2002) extended the cognitive rehabilitation and errorless learning paradigms to dementia populations. As previously reported this study concluded that no scores on neuropsychological measures appeared to predict outcome. However, inspection of the extensive data suggests that participants categorised by the authors as 'good learners' appeared to have better residual explicit memories. Again, as previously reported, the study's intervention comprised several strategies (mnemonics, vanishing cues and spaced retrieval), the combination of which may have adversely impacted on the learning of the more severely impaired participants (as well as those with more significant impairments of executive functioning) who may have found certain aspects difficult to apply. Again however, without statistical analysis of the relationship between learning and severity of memory impairment, it is not possible to draw conclusions from the results.

Metzler-Baddeley and Snowden (2005) compared errorless and errorful learning of familiar objects and novel face-name associations. The study's four participants were also encouraged to self-generate and use mnemonics, however this was discontinued for two participants who found it too demanding. Participants learned significantly more novel information under errorless conditions (albeit three participants also learned well in the errorful condition). For the familiar material, although no individual comparisons were significant, the group recalled significantly more familiar items under errorless conditions. The authors suggested that errorless learning might be of greater benefit in situations where it is difficult to apply meaningful mnemonic strategies and for the more severely impaired who find these techniques too demanding. It is worth noting here, given the outcome of the Thoene and Glisky (1995) study, that it may be generating rather than using these strategies which is demanding, as the severely impaired participants in this study learned well with experimenter-generated mnemonics. Metzler-Baddeley and Snowden (2005) also discuss the notion of a trade-off between effort and errorlessness which was particularly apparent for one participant. This participant learned familiar material (successfully self-generating and using mnemonic strategies) equally well under errorless and errorful conditions. However, the authors note that when learning novel material (for which they suggest effortful processing is more difficult due to the absence of semantic information to facilitate the generation of meaningful retrieval cues) this participant performed better errorless conditions. They concluded that the efficient use of mnemonics may override any beneficial effects of errorless learning, albeit errorless learning remains preferable to errorful learning in situations where effortful processing is difficult. However, this conclusion is based only on one participant, and the authors themselves acknowledge that their study's very small sample size significantly compromises the generalisability of its conclusions.

A similar issue was raised by Lloyd, Riley and Powell (2009), who found participants made significantly fewer errors under errorless compared to trial and error conditions on a route learning task. However, it was noted five of the 20 participants made more errors under errorless conditions. The authors suggest that these participants appeared to benefit from errors made in previous learning trials and that they possessed sufficient residual explicit memory to self-correct previous errors and improve their performance under errorful conditions. No comparisons are reported between participants and their neuropsychological assessment data, although the authors note that their conclusions are consistent with previous findings (e.g. Metzler-Baddeley and Snowden (2005)) that people with more severe impairments of explicit memory show a greater benefit for errorless over errorful learning.

Mimura and Komatsu (2010) also addressed the effort/errors trade-off. They identified a robust advantage for errorless over errorful learning in both amnesic and Alzheimer's disease participants and a "circumscribed" benefit from effort for the amnesic participants but only on a free recall test. The same benefit was not evident on a cued recall test. The authors considered the most likely explanation to be that effort becomes beneficial when environmental support is lacking and self-initiated retrieval is required. Memory assessment of the amnesic participants (mean WMS-R delayed recall score 61.6) indicated severe impairments, yet these participants benefitted from learning conditions associated with greater effort (MVC and category generation) whilst those with Alzheimer's disease did not. Given the limited neuropsychological assessment data available, it is unclear what factors prevented the Alzheimer's participants benefitting from effortful learning. However it is possible that the additional cognitive impairments (including impairments of executive functioning) that are often associated with the onset of Alzheimer's (Colette, Van der Linden & Salmon, 1999) impacted on their ability to use effortful strategies effectively.

Tailby and Haslam (2003) and Page, Wilson, Shiel, Carter & Norris (2006) primarily aimed to address the theoretical disagreement regarding the nature of the errorless learning advantage. Both studies categorised participants by impairment severity, the former with a mild/no impairment, a moderate and a severe impairment group (classified by a Wechsler Memory Scale, Third Edition (WMS-III; Wechsler, 1997) Verbal Memory Index of <70, 70-89 and >90); the latter with a severely impaired group (RBMT score <4 and WMS-R delayed story recall score of 0) and a moderately impaired group (RBMT 4-6 and delayed story recall score of less than half their immediate score). Tailby and Haslam's study introduced the concept of 'self-generated' errorless learning, adding an 'effortful' component to this approach by describing a target word by reference to various semantic properties and asking participants to name it. The study compared participants' word learning abilities under this, errorful and standard errorless conditions. All groups learned best in the self-generated condition, although the authors were unclear whether this advantage arose from the cues provided, participants' self-generation or both. It was concluded that the self-generated condition was superior to standard errorless learning, and in both conditions little information was lost over time. However, whilst both moderately and mildly impaired groups performed better than the severely impaired under standard errorless conditions, the difference in performance between errorful and standard errorless performance was greater for the severely impaired group, leading the authors to suggest that the errorless learning advantage is greatest for this group. The authors emphasise the value of making use of participants' semantic memory systems and encouraging active engagement in the (errorless) learning process regardless of memory impairment severity.

Page et al. (2006) reported a general advantage for errorless over errorful learning for both severely and moderately-impaired groups across two experiments. This advantage was reliable for both groups under implicit teaching instructions, whilst under explicit teaching instructions it was reliable for the severely impaired group whilst the moderately impaired group showed only a numerical advantage for errorless learning. The authors also concluded that the moderately-impaired group performed better than the severely impaired in circumstances where participants were able to use their additional residual explicit memory.

Two other studies were identified as relevant to the question of impact of severity of memory impairment. Bier et al. (2008) investigated face-name learning in 15 participants with Alzheimer's disease across five learning conditions (errorless and errorful). They identified few useful relationships between outcome and severity of impairment save that, not unsurprisingly, the best performers had better residual episodic memory. It should be noted however that their procedure involved learning several names in one session, which may have been too demanding for those with more severe impairments. Their case study analysis also revealed that two of their four best performing participants had worse episodic memories. Although these observations lack methodologically robustness, they do suggest that some individuals with severe memory impairments may be able to learn as well as those with less severe impairments. The other study was an investigation of spaced retrieval and other schedules of practice for people with dementia (Hochhalter et al., 2005), which found that success on a verbal learning task could be predicted by participants' performance on the immediate recall trials of the Hopkins Verbal Learning Test (Benedict et al., 1998). Again, however, this study was compromised methodologically by its small sample.

Most of the studies included in this review incorporated some memory assessment as part of their neuropsychological evaluation of participants, and many made some attempt to analyse the relationship between assessment data and learning performance. A wide range of assessments have been used, with limited consistency across studies. Of the twelve studies identified for this review which discuss this relationship, six used one or more subtests and/or index scores from either the WMS-R/WMS-III, with verbal and delayed memory scores appearing most frequently. Two studies used the Rey Osterrieth Complex Figure (Rey, 1941). Four studies used the RBMT and two the Doors and People Test (Baddeley, Emslie & Nimmo-Smith, 1992). Most contain at least one measure of verbal memory impairment.

A further complicating issue, particularly in those studies that divide participants into groups based on the severity of their impairments, is the inconsistent definition of impairment severity itself. Studies generally classify impairment severity into no more than three types (mild, moderate and severe). Classification may be relatively straight-forward across studies using the same measure, for example the RBMT, where a score of 3 or below is classified as severe impairment. As reported, however, a range of assessment procedures have been used, and classification inconsistencies can be identified. For example, Tailby and Haslam (2003) classified participants as severely impaired if they scored less than 70 on the WMS-III Verbal Memory Index and moderately impaired if they scored between 70 and 89, yet scores at the upper end of this classification would place them in the average range. Likewise some studies have included in their experimental groups participants with little apparent memory impairment (e.g. Riley & Heaton, 2000). One important consequence of this classification inconsistency is that extreme caution is required when considering the implications of the collective findings of studies which attempt to make distinctions between groups of participants based on impairment severity.

Conclusions and clinical implications

There is much evidence to support the use of various strategic memory rehabilitation interventions. It also appears from the studies reviewed that there are some differences in terms of the relative effectiveness of different teaching-based intervention for people with differing degrees of memory impairment. It is noteworthy that comparison of different strategies is limited, and unsurprisingly, the main finding of the studies reviewed is that people with more severe memory impairments learn less well than the less severely impaired. Given the disparate nature of the studies reviewed, their methodological flaws and the issues around inconsistent measurement and defining impairment severity, it is challenging to draw definitive conclusions in terms of which interventions work best and for whom. Any advice to clinicians must therefore be considered tentative at best. Nevertheless, it may be useful for clinicians to hold in mind these tentative conclusions when planning memory rehabilitation interventions.

A summary of the conclusions that follow is set out in Table 2. This table sets the conclusions in relation to different categories of memory intervention, in the context of the evidential strength/classification of the studies reviewed. This is based on the revised American Academy of Neurology (AAN) classification system (Class I-IV evidence) (American Academy of Neurology, 2004; www.aan.org). In this classification, examples of Class I studies are prospective randomised controlled trials (RCTs) with masked outcome assessment, Class II are prospective matched group cohort studies with masked outcome assessment that meet specific criteria for this class or RCTs that lack one criterion for Class I classification. Class III include other controlled trials where outcome assessment is independent of treatment, and Class IV is evidence from uncontrolled studies, for example case reports. It can be seen from Table 1 that 14 of the studies included in this review are classified as Class III studies, and one (Pitel et al, 2006) as Class IV.

Table 2 – Summary of Conclusions

Type of Impairment / **Memory intervention**	**Executive Functioning (EF)**	**Severity of Memory Impairment (SMI)**
Mnemonics (imagery-based)	– Exercise caution before using with people with EF impairments – Conclusions based on evidence from Class III studies	- Taught and self-generated mnemonics effective for less severely impaired; self-generated may be preferable as require greater effort - More severely impaired can benefit from mnemonics but these should be taught not self-generated – Conclusions based on evidence from Class III studies
Cueing	No evidence	– Less severely impaired benefit more from increasing assistance and more rapid cue fading – More severely impaired benefit more from decreasing assistance and more gradual cue fading – Conclusions based on one Class III study with small sample (12)
Retrieval Practice	No evidence	– Less severely impaired benefit more than more severely impaired – Conclusions based on one Class III study with small sample (11)
Errorless Learning	– Emerging view that executive functioning impairments can adversely affect response to errorless learning - Conclusions based only on examination of individual data from Class III studies and from one Class IV study	– Traditionally used with more severely impaired but can benefit people with varying degrees of impairment – With more severely impaired focus on error constraint over active involvement/effort – Conclusions based on evidence from Class III studies
Effortful Processing	No evidence	– Focusing on effort (even if at expense of increased errors) may be preferable for those with less severe impairments – Conclusions based on evidence from Class III studies

When using imagery-based mnemonic approaches, benefit can be gained by people with memory impairments of varying severity. The less severely impaired can benefit from both taught and self-generated imagery. However given the issues relating to the effort/errors trade-off, consideration should arguably be given to self-generated imagery, as this is likely to require greater effort. The more severely impaired can also benefit from imagery mnemonics, but these should generally be taught and not self-generated. Caution should be exercised before using mnemonics with people with executive functioning impairments, who may not benefit from this approach to the same extent as the executively unimpaired.

When considering cueing procedures, the only study to address this issue (Riley & Heaton, 2000) concludes those with milder memory impairments benefit more from increasing assistance and more rapid fading, whilst the more severely impaired require more gradual, decreasing assistance. In terms of the balance between effort and errors, the more severely impaired may therefore require fewer errors with less effort, whilst the mildly impaired benefit more from effort even if it means making more errors. Although one study (Thoene & Glisky, 1995) found taught mnemonics to be superior to the original MVC, the form of cueing used with these severely impaired participants was arguably not the most helpful. Thus mnemonics should not necessarily be preferred to cueing for the more severely impaired. There is no evidence which considers the relationship between executive impairments and cueing procedures.

With regard to retrieval practice, the only study reviewed (Hochhalter et al., 2005) suggests that those with less severe impairments of verbal memory will benefit more from this approach, albeit its findings were significantly compromised by its small sample. Nevertheless, other studies report favourable outcomes for such approaches (e.g. Hillary et al., 2003), albeit no distinctions were made between participants according to impairment severity. Retrieval practice may therefore be considered for the less severely memory impaired, particularly given recent findings that this can benefit even when other mnemonic strategies are less effective (Sumowski et al., 2010). There is no evidence in relation to the impact of executive impairments on retrieval practice.

Traditionally, errorless learning has been used successfully with participants with severe memory impairments (Baddeley & Wilson, 1994), although people with varying degrees of memory impairment can benefit from errorless learning approaches. The studies reviewed suggest that the more severely impaired fair better when interventions focus on constraining errors rather than maximising effort whilst the less severely impaired may benefit from more active involvement/effort even if this is at the expense of making some errors. At a theoretical level, this relates to the concept of effortful processing (Komatsu et al., 2000) which suggests that increased cognitive effort improves the chances of success in new learning situations and that those with less severe impairments of explicit memory prosper more when engaged in more effortful learning situations in which they are provided with less help. By contrast those with greater explicit memory impairments are more affected by making errors, as recognising and responding to errors is dependent on their impaired explicit memories. This explains why they benefit more from approaches which focus on error elimination/reduction.

Clinicians should be aware of studies that have reported an adverse impact of executive functioning on errorless learning at an individual level. This view has not been substantiated in methodologically robust studies relating to rehabilitation of memory per se, albeit in studies relating to the treatment of anomia (e.g. Fillingham et al., 2006) impairments of recognition memory and executive functioning have been found to impact negatively on outcome. Ptak, Van der Linden and Schnider (2010) note that in interventions such as errorless learning which rely predominantly on implicit memory processes, consideration should be given to the fact that knowledge acquired in this way can lack flexibility. They therefore recommend behaviour management and using memory aids for those with severe memory impairments. Where teaching strategies are used, it appears therefore that for the severely impaired the trade-off between errors and effort should favour error reduction/elimination at the expense of effort. For the less severely impaired, strategies that promote effort (albeit still using errorless principles) such as self-generation may also be beneficial. However, the benefit from effort is most likely to emerge in the absence of environmental support such as cues and where the memory impairment is not accompanied by significant impairments of executive functioning. Although one study (Tailby & Haslam, 2003) did identify self-generation as being useful for the severely impaired, the definition of severity in this study was such that some of the participants in this group would not have been classified in other studies as severely impaired. On this basis and given the reported findings of the usefulness of self-generation in imagery mnemonics, it may therefore be wise to exercise caution before using such effortful strategies with those with severe memory impairments.

It should also be noted that in the majority of the studies discussed, the main issue of relevance to the present review has been the extent to which the effectiveness of strategies has been affected at a general level by the presence of these impairments. The tentative suggestions in relation to the impact of executive functioning impairments and severity of memory impairment may provide clinicians with some guidance about who is suitable for memory rehabilitation interventions. However, there has been little research that has investigated the differential influence of these cognitive impairments on the effectiveness of the different teaching strategies. As such it is difficult to provide any guidance to clinicians in relation to whether particular strategies are more or less likely to work with a particular individual.

It is recognised that decisions about which teaching strategy to use with a particular client will also vary according to a range of additional considerations. These include the nature of the learning task; for example learning face-name associations can be facilitated using a range of approaches (see Clare et al., 2002), however route learning may be difficult to facilitate using vanishing cues or imagery-based mnemonics. Other factors include the relative difficulty of the task at hand for the individual learner and the practical implications of using that approach. Alongside the evidence base, all these factors need to be taken into account when considering individuals for memory rehabilitation interventions.

Future research

The evidence relating to the impact severity of memory impairment on candidacy for different memory rehabilitations intervention is certainly more developed than that in relation to the impact of executive functioning impairments. That said, studies have rarely sought to test such predictions directly, and these questions have usually featured as secondary aims in these studies. Future research should therefore aim to address these issues as a primary aim. The secondary nature of this question has meant there is much variability across the measures used to assess participants' memories. Consistency of measurement and severity definition across studies would enhance the compatibility of their findings. Attention should be paid to these factors in future studies.

As reported, there has been little research that has investigated the differential influence of these cognitive impairments on the effectiveness of the different teaching strategies. As such, one useful focus for future research would be the comparison of different teaching strategies across samples with different profiles of neuropsychological impairment. This might include participants with lower levels and different profiles of executive functioning, as little is yet known regarding those aspects of executive functioning which most impact on the learning process. The findings from such research may guide clinicians when selecting strategies to use with individual clients.

There appears to be an emerging general rule that strategic approaches favouring effort (at the expense of an increased risk of errors) tend to be preferable for those with less severe impairments, those with severe memory impairments will benefit more from errorlessness at the expense of greater effort. Fillingham et al. (2006) suggest that the outcome of errorless relative to errorful learning may reflect the degree of amnesia and attentional-executive dysfunction and that the errorless preference for the severely impaired arises as they lack the necessary cognitive resources to filter out or inhibit learning during errorful trials. Of particular interest may be to establish at what level of impairment severity this balance preference begins to change. It is important to note this trade-off is not straight-forward and will be further complicated by a range of factors. These include the presence of additional cognitive impairments and the nature and difficulty of the learning task. As reported, some studies have begun to consider these factors in relation to the rehabilitation of memory impairment, however this has usually been of secondary importance. Future studies should therefore also pay further consideration to the interaction between such impairments and severity thereof and task nature/difficulty.

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EMPIRICAL PAPER

A COMPARISON OF THE EFFECTIVENESS OF IMPLICIT AND EXPLICIT INSTRUCTIONS IN TEACHING PEOPLE WITH ACQUIRED MEMORY IMPAIRMENT.

ABSTRACT

Background: Teaching instructions in memory rehabilitation approaches such as the method of vanishing cues can be designed to encourage the use of either explicit or implicit memory processes. It has been suggested that within the memory impaired population, those with greater residual explicit memory are more likely to benefit from instructions that encourage the use of these processes, provided the retrieval process during the teaching trials is effortful but relatively effective.

Method: This prediction was tested in the current study which compared teaching instructions which encouraged the use of either explicit or implicit memory in learning word lists amongst 34 participants with a history of acquired brain injury and memory impairment of varying degrees of severity. Learning was assessed using two immediate and two delayed recall tests, though because of floor and ceiling effects only scores on an immediate free recall and a delayed cued recall test were entered into the analysis. To allow the investigation of the role of retrieval effort and executive functioning, participants learnt a set of easy and a set of hard words, and they were divided into a more impaired and a less impaired executive functioning group according to their performance on the Delis-Kaplan Tower test.

Results: Explicit instructions were significantly more effective than implicit ones on the immediate test ($F=8.68$; $p=.007$) and the difference approximated significance on the delayed test ($F=3.51$; $p=.072$). Consistent with the hypothesis, there was a significant instruction-x-memory group interaction on the delayed test ($F=4.83$; $p=.037$), indicating that those in the group with less impaired memories received more benefit from the explicit instructions (relative to the implicit instructions) than did those in the group with more impaired

memories. This interaction was also significant on the immediate test for the easy words (F=5.21; p=.031), but not for the hard words (F=1.87; p=.183). Executive functioning did not interact with other variables on the immediate test or on the delayed test for the easy words. However, on the delayed test for the hard words, better performance under explicit instructions was shown by those with less impaired memory and less impaired executive function, those with less impaired memory and more impaired executive function, and those with more impaired memory and less impaired executive function – but not by those with more impairments in both memory and executive functioning. Considering just those with more impaired memory, there was a significant instruction-x-executive group interaction (F=10.14; p=.010), indicating that those impaired on both functions failed to benefit from explicit instructions to the same extent as those with less impaired executive functioning. Indeed, those impaired on both functions showed a non-significant trend towards performing worse with explicit instructions for the hard words (t = -1.765, df = 20, p = .108).

Discussion: Explicit instructions were generally more effective than implicit instructions, but there were circumstances in which implicit instructions were as effective. As expected, these circumstances related to the level of memory and executive impairment shown by participants and to the degree of effort required in learning the items (indicated by item difficulty). Possible implications of these results for future research and clinical practice are discussed.

Keywords: acquired brain injury, learning strategies, memory training, memory disorders, implicit memory.

INTRODUCTION

This study relates to the theoretical division between implicit and explicit memory systems. According to Page, Wilson, Shiel, Carter and Norris (2006), explicit memories require conscious recollection of the previous experience on which the memory is based, whereas the effects of implicit memory are evident in the absence of such recollection. In neurorehabilitation services, much time is devoted to the rehabilitation of memory impairments, there has been much research around the techniques and mechanisms of learning for people with such deficits. A number of key approaches and techniques have now been established, and these are briefly introduced below.

Principles and techniques of rehabilitation teaching strategies

A range of principles and techniques are now used in the rehabilitation of memory impairment. Their origins lie in the behavioural studies of animal learning and the practical application of the behavioural findings in the learning disability field (Sidman & Stoddard, 1963), as well as in education generally (e.g. Skinner's teaching machines, Skinner, 1968)). The key principles are the avoidance of errors (errorless learning), cue fading and effortful processing.

The main aim of errorless learning is to prevent people from making mistakes in new learning situations, which can be done in a variety of ways, and following Baddeley and Wilson (1994), this principle has been widely adopted in memory rehabilitation work. They argued that the recognition and elimination of errors is dependent on explicit memory. As people with impairments of explicit memory often do not retain sufficient explicit memory functioning to recognise errors they make during in the learning process, they therefore struggle to learn from their mistakes. The arguably contradictory principle of ‘effortful processing’ (Komatsu, Mimura, Kato, Wakamatsu & Kashima, 2000; Riley & Heaton, 2000), suggests that factors such as depth of processing and cognitive effort affect the chances of success in new learning situations. Both these principles underpin the different behavioural teaching strategies used in the rehabilitation of memory impairment.

The literature identifies a wide variety of teaching strategies for improving memory performance in people with memory impairment, and these can be used in isolation or in conjunction with others. The main distinction between these techniques is that some involve cueing, whilst others do not. Cueing is a technique whereby a hierarchy of retrieval prompts is provided to the learner, and this can be done in different ways (Riley & Heaton, 2000). In cueing with increasing assistance, the learner initially has the chance to respond with no prompt or with the weakest prompt. The level of prompting provided can be gradually increased until the correct response is given, with all learning trials following the same format. In cueing with decreasing assistance, the learner is first provided with the strongest prompt (often the full response). Cues are then faded in a pre-determined fashion, once the learner meets certain pre-determined performance criteria (e.g. correct retrieval of the target response twice consecutively), with the prompts moving from strongest to weakest, following which unprompted trials may also be used. There are various ways in which cues can be faded, with factors other than the direction of the assistance being variable, for example the speed of fading. One commonly used application of cue fading is the method of vanishing cues (MVC), which involves the gradual fading of cues/prompts to enable stimulus control to be transferred to the naturally occurring antecedents for the response (Skinner, 1968).

Some teaching strategies do not involve cueing. One example is retrieval practice, which can also be applied in a variety of ways (e.g. Hochhalter, Overmier, Gasper, Bakke, & Holub, 2005). One commonly used application is spaced retrieval (differentially referred to as expanding rehearsal) involves presentation of the material to be learned followed by immediate testing and thereafter further testing following gradual increases in the period of retention.   Both spaced retrieval and the MVC are regularly combined with errorless learning principles in clinical practice. However their very nature makes it very difficult to prevent errors altogether, and as such they may be characterized as trying to balance the aim of withdrawing cues with that of minimizing errors.

Is the effect dependent on explicit or implicit memory?

There is much debate in the literature, summarised by Wilson (2009), regarding the extent to which these approaches and techniques, in particular errorless learning, depend on explicit and/or implicit memory. The opinions expressed are wide ranging with some (e.g. Baddeley & Wilson, 1994) arguing that the effectiveness of errorless learning (EL) for memory impaired people is based on their increased reliance on implicit memory, a system which is generally spared in amnesia (see Graf, Squire & Mandler, 1984). However, others (see Hunkin, Squires, Parkin & Tidy, 1998) argue that this advantage accrues due to the impact of preventing errors on remaining explicit memory ability. Tailby and Haslam (2003) argue predominantly for this latter view, however they emphasise the complexity of the issue and suggest that reliance on different processes may vary between individuals. Rather than viewing this issue in simplistic terms (i.e. whether the techniques facilitate implicit or explicit memory), it may be more useful to accept that both systems may be facilitated by the techniques, and to investigate what factors influence the extent of this facilitation.

Another factor that is of relevance to whether these approaches impact on explicit or implicit memory is whether the teaching instructions encourage explicit or implicit processing. Various studies have evaluated the effectiveness of the different approaches outlined above. Sometimes teaching instructions have been used that encourage reliance on explicit memory (e.g. Riley & Heaton, 2000; Riley et al. (2004)). In these studies, the instructions used on the MVC learning trials made explicit reference to the fact that the material had previously been presented, and so the instructions encouraged explicit recall of the material during the learning trial. It was suggested that the success of the MVC would be enhanced when explicit learning is required, and that the method would therefore be more beneficial with less severe memory impairments. In some other applications of similar teaching methods, the instructions have made no explicit reference to the previous presentation of the material and the instructions may thus have encouraged implicit memory for the material. For example, participants in a study by Elizabeth Glisky and colleagues (e.g Glisky, Schacter & Tulving, 1986) learned computer-related vocabulary. On subsequent testing, their knowledge was tested firstly by being presented with definitions and being asked to verbally produce the target word and secondly by matching a number of target words to a number of definitions. In neither test was any reference made to their previous learning of the material. In neither test was any reference made to their previous learning of the material. This has led to suggestions that the successful operation of the MVC procedure may rely on implicit memory processes (Hunkin & Parkin, 1995). In this study the benefit of the MVC condition was only apparent after a six week delay, and it was suggested that by this stage explicit memory would be much reduced, thus requiring reliance on implicit processes.

It is evident that many studies have investigated promoting the use of either the explicit or the implicit memory system. However, there has been little research that directly compares the two. One study (Page et al., 2006) identified no difference between instructions promoting the use implicit/explicit memory, however the main aim of this study was to identify the memory system predominantly responsible for the errorless learning advantage. The aim of this study was to direclty compare the effectiveness of these two different types of instruction.

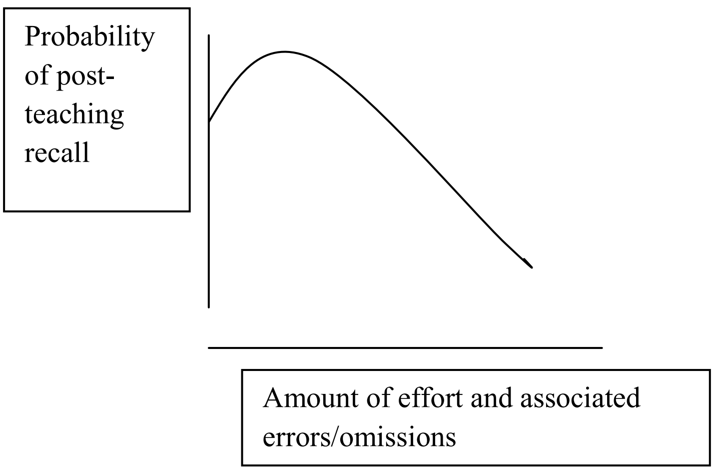
Factors influencing the impact of the MVC on explicit memory

Riley and colleagues (2000, 2004) have investigated in detail the factors that may influence the impact of the MVC on explicit memory. These include task or item difficulty alongside those of effort and error reduction. As previously stated, part of the rationale for the avoidance of errors for those with impairments of explicit memory is that they can impair learning. However, it has also been suggested (Baddeley & Wilson, 1994; Pitel et al., 2006) that error monitoring and correction is also dependent on the executive system, and as such those with impairments of executive functioning may be particularly vulnerable to the effects of errors. This study therefore also sought to clarify the impact of executive functioning when learning using the MVC.

On the basis of research findings in both cognitive psychology and neuropsychological rehabilitation, Riley and Heaton (2000) and Riley, Sotiriou and Jaspal (2004) suggested that explicit recall of material during teaching trials using the MVC can facilitate subsequent recall of that material, provided that trial attempts are effortful and relatively errorless. The 'effortful processing' principle described above suggests that the beneficial effects of prior recall will be greater if the information is recalled with effort than if recalled with ease.

However, due to the potentially adverse effect of errors on learning for those with acquired memory impairments (Baddeley & Wilson, 1994), an excess of errors should be avoided wherever possible. In a study relating to learning in Korsakoff patients Komatsu et al., (2000) referred to this as a trade-off, between errors/omissions and effort. Increasing the effort of teaching trial recall runs the risk of increasing errors/omissions; but making the teaching trial recall completely errorless may come at a cost in that the effortful processing required to enhance the chances of successful retrieval is reduced. This suggests that the optimal conditions for learning in the MVC may be associated with striking a balance between effortful teaching trial retrieval that is associated with a relatively small number of errors/omissions (see Figure 1).

Figure 1. Relationship between errors, effort and probability of recall, suggested by Riley et al. (2004).

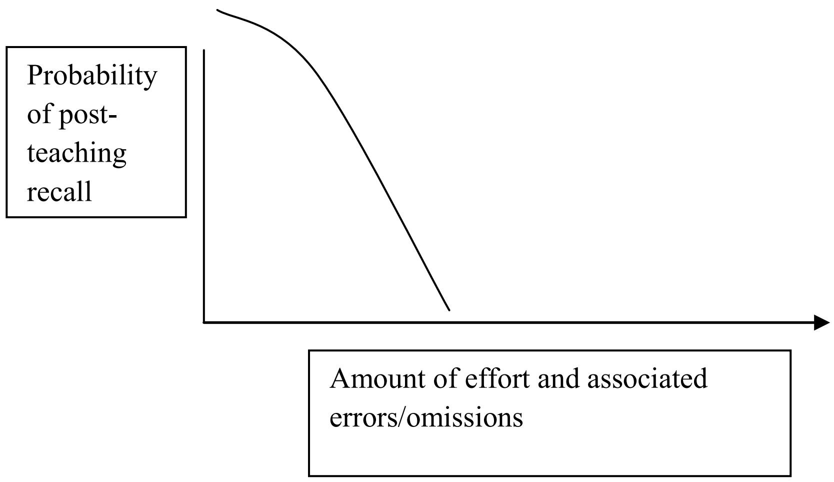


To investigate this claim, Riley et al. (2004) compared an MVC procedure that instructed the participant to recall the material on the learning trial ("explicit instructions") with a procedure that simply presented the material on the learning trial and so did not require any implicit or explicit recollection of the material. They found that the former procedure led to better subsequent free recall for both those with memory impairments and a sample of those without any memory impairments. The MVC procedure was associated with a modest number of errors/omissions in one of the studies reported. Consistent with the theory outlined earlier, the number of errors/omissions (suggestive of greater effort) was positively correlated with the extent to which the MVC procedure was superior to the non-recollection condition. In other words, the 'boost' to learning obtained from explicit teaching trial recall was greater when there was evidence (from the number of errors and omissions) that the teaching trial recall had been more effortful for the individual. Riley and Heaton (2000) similarly reported that a modest number of errors or omissions occurred within two MVC-type procedures, and that the number of errors/omissions was positively correlated with the amount of material recalled.

Riley and Heaton (2000) suggested that the responsiveness of learners to different variations of the MVC will depend on the severity of participants' memory impairments and the ease/difficulty of the items to be learned. They argued that to achieve a balance between effort and error, greater assistance will be needed during teaching trial recall attempts with more difficult learning tasks and when the learner has more severe memory deficits (without which recall attempts are more likely to fail). The study compared two teaching methods that vary according to how much assistance the learner receives when attempting recall during teaching trials. They found that the method that offers more assistance to the learner was more effective for people with more severe memory impairments and for items that were more difficult to learn, whereas the method that offers less assistance was more effective for those with less severe impairments and for items that were easier to learn.

There may be another reason why the level of memory impairment has an effect on the occurrence of the boost from explicit teaching trial recall. The original theory regarding errorless learning in neuropsychological rehabilitation (Baddeley & Wilson 1994) suggested that errors are problematic in learning when the learner cannot recognize them as errors; that this recognition of responses as errors is dependent on explicit memory; and that therefore errors are particularly problematic for those with severe memory impairment because that impairment will be of explicit memory, and they will thus be highly vulnerable to the negative impact on learning of errors. Errorless learning is meant to be particularly helpful for those with severe memory impairment because it utilises their intact implicit memory. So those with more severe memory impairments may be less likely than those with less severe impairments to benefit from this explicit boost, because it may be very difficult to achieve effortful retrieval without impairing learning because of the more frequent occurrence of errors (see Figure 2 and compare with Figure 1).

Figure 2. Relationship between errors, effort and probability of recall, for those with severe impairments of explicit memory.



The impact of explicit vs. implicit instructions

As noted earlier, whereas the two studies by Riley and colleagues used explicit instructions for the teaching trial recall, other applications of the MVC have used implicit instructions that make no reference to the fact that the learner had previously been presented with the material to be learnt. The existence of these two differing approaches to MVC teaching raises questions about their relative effectiveness. If they are followed, implicit instructions should result in the person not making any conscious effort to recall the material (i.e. they will not use their explicit memory to retrieve the material). Instead, their performance will depend on their implicit memory alone. The boost that comes from the explicit recall of the material during the teaching trial will, in this case, not occur. A widely-accepted theoretical assumption is that the contributions of the implicit and the explicit systems to a specific act of memory are additive (e.g. Jacoby, 1991). This gives rise to the possibility that explicit instructions may be more effective than implicit instructions in circumstances that favour the occurrence of this boost – namely, when the learner has less severe memory impairments and when the teaching trial recall is associated with a modest, but not excessive, number of errors/omissions (indicating greater effort during the teaching trials).

The present study

This possibility was tested in the present study which included participants with a range of acquired memory impairments. Participants with varying degrees of memory impairment learnt word lists under two MVC teaching conditions, one with instructions designed to encourage the use of explicit memory and the other with instructions designed to encourage the use of implicit memory. Memory performance was subsequently evaluated on a test (cued recall) which recreated the conditions of a later learning trial and on a free recall test (which is most removed from these conditions). These cued and free recall tests were given both immediately after learning and then again after a week's delay. The material learned was also varied in that some was relatively easier and some relatively more difficult. The main hypothesis tested was that those with less severe memory impairment will show a greater improvement under explicit instructions (relative to implicit instructions) than those with more severe memory impairment – in other words, that they will show a greater explicit boost than those with more severe memory impairment.

The analysis also investigated the role played by the effort involved in learning each of the items (assessed by the number of errors made during the teaching trial recall) and the participants' level of executive functioning. As suggested earlier, effort may influence the extent of the explicit boost. However, the development of a specific hypothesis in relation to the main effect of the number of errors (effort) was precluded. This was due to the difficulties in estimating the extent to which errors on specific items would occur, and as it is difficult to estimate the optimal level of errors that may be required to maximize the explicit boost (particularly given that this will vary according to the severity of the individual's memory impairment). The level of executive impairment was also included in the analysis due both to its potential role in monitoring for and responding to errors and to the increasing interest in the literature about the impact of executive functioning difficulties generally (Robertson & Murre, 1999; Clare & Jones, 2008).

METHOD

Participants

The participants were recruited via the day centres of two branches of a well-known charity providing day services for adults in the community with a history of acquired brain injury. Potential participants were provided with an information sheet (see Appendix 2) about the study. The criteria by which participants were included in the study were as follows. Participants were all native English language speakers and between 18 and 65 years. They had to be capable of giving informed consent (see Appendix 3 for consent form). There was to be no history of brain injury within the last 12 months. Those with severe attention deficit or marked language impairments (as judged by staff involved in their care) were excluded from the study.

Forty-two participants were recruited of whom 34 completed the study. Of the eight who did not complete, two were excluded from the study as they stated clearly that they were using explicit memory strategies when given implicit teaching instructions, two did not continue for medical reasons, whilst the reasons for the remaining four participants not completing were not clear. Of those who completed the study, 27 were male and seven female, and they had an age range of 28-64 years, (mean 50 years, SD 10 years). Of the group, 18 had acquired their injuries from a traumatic brain injury, nine from a stroke and four a brain tumour/cyst or abscess, requiring neurosurgical intervention. One had sustained carbon monoxide poisoning, one a hypoxic brain injury and one had acquired their brain injury in the course of neurosurgical intervention for epilepsy. The time since injury varied between participants from two years to 53 years (mean 17 years, SD 16 years). Demographic information together with neuropsychological screening assessment results are provided in Table 1. The study was granted ethical approval by the University of Birmingham Research Ethics Committee (see Appendix 4).

Design

A mixed design was used with two within-subjects factors (implicit teaching instructions vs. explicit teaching instructions; easy items vs. hard items), and three between-subjects factors (list order, severity of executive impairment and severity of memory impairment). All participants learned two words lists (A and B), one with explicit teaching instructions and one with implicit instructions. Word list order and type of teaching instruction were counter-balanced across four possible combinations to avoid possible order and list effects. The words were chosen from a list used in a study by Jacoby (1998). Each list contained ten five letter words presented in the same order to all participants. The number of words in the lists was based on the outcome of a pilot study, in which two participants learned two word lists under the same conditions, save that each list contained only eight words, and there were eight learning trials. The number of words and learning trials was revised for the main study. Each word list contained five 'easier' and five more difficult words, with items and ratings for item difficulty being based on words used in a study by Jacoby (1998). Words with high frequency of usage and set size (the number of five-letter word completions for the stems given by participants in this study) were rated as easier and those with lower frequency and set size were rated as more difficult. To control for variability in word difficulty, overall frequency and set size amongst easier and more difficult words was compatible in both lists. All 20 words started with a different letter to minimize opportunities for confusion between items. The order of items in terms of item difficulty was consistent across the two lists. The word lists used in this study and together with their frequency rating and set size as described by Jacoby (1998) are set out in Appendix 5.

Materials

For each word, a set of five cue cards were constructed. The first card contained the whole word (e.g. GUIDE), whilst the subsequent cards contained one or more letters followed by a number of dashes to indicate the missing letters (e.g. GUID_, GUI__, GU___, G____), in line with the MVC methodology.

Measures

The dependent variables were the number of words correctly recalled across four tests (immediate free recall, immediate cued recall, delayed free recall and delayed cued recall). Measures of immediate and delayed recall were incorporated to distinguish between short and long term retention. Participants were awarded a mark if they clearly stated the target word. Implicit memory is sensitive to the way it is tested and its effective use relies on re-creation of the original learning conditions, and it is therefore very sensitive to the way in which the memory is tested. Various memory models, for example the encoding specificity principle (Tulving, 1983) suggest that memory test performance is partly determined in part by the degree of overlap between the processes performed during the learning phase and those performed during the test. Greater overlap will produce better test performance; see Riley et al., (2004) for more detail. This principle is thought to apply to both explicit and implicit memory. However, as implicit memory is assumed to rely predominantly on perceptual processes, it is therefore particularly dependent on the person performing similar processes in both learning and test situations and requires the test situation to be very similar to the learning situation, hence the inclusion of measures of cued recall. As more conceptually-driven cognitive processes sustain performance on tests of explicit memory, they are considered to be less dependent on overlap between learning and test situations, and for this reason measures of free recall were also included. Riley et al. (2004) compared two teaching strategies, and tested implicit memory in a number of different ways. Their results emphasized the importance of investigating the way in which implicit memory is tested. Implicit instructions may lead to better performance on an implicit test which re-creates the conditions of the learning trial (e.g. cued recall), but may not lead to better performance when this is not the case (e.g. when the memory is evaluated using a free recall test).

The measure of severity of memory impairment was provided by the raw total recall score from Word Lists subtest of the Wechsler Memory Scale - Third Edition (WMS-III; Wechsler, 1997). This test involves four successive learning trials of a list of 12 words and was chosen because of its close resemblance to the experimental task. Raw scores were used to avoid the effects of any age-related cognitive decline, as this study relates to memory per se, regardless of the cause of variation. The measure of executive functioning was provided by the raw total achievement score from the Tower Test from the Delis Kaplan Executive Functioning System (DKEFS; Delis, Kaplan & Kramer, 2001). This test was chosen for a number of reasons. Subsumed under the collective term ‘executive functioning’ are a number of different cognitive process, but it is unclear which of these may impact on the learning process. It was therefore important to choose a test which requires a range of executive skills. The Tower Test claims to tap spatial planning, rule learning, inhibition and establishing and maintaining cognitive set. Likewise it was important to choose a task which participants were likely to find engaging given the potentially disengaging nature of the experimental task. A measure of premorbid cognitive functioning was provided by the Wechsler Test of Adult Reading

(WTAR; Wechsler, 2001). This was included to provide a rough estimate of the extent of participants' acquired memory impairment. Participants' demographic details and scores on these tests are summarised in Table I.

Procedure

Six protocols were written (one for each possible participant contact), to ensure strict adherence to the study procedure (see Appendix 6). Each participant was seen on three separate occasions. On each of the first two contacts, participants were asked to learn one of the two word lists (list A or list B), on each occasion under different teaching instructions (explicit or implicit). Both sets of instructions used the MVC procedure. For each word there were six learning trials. The number of learning trials was again based on the outcome of the pilot study. The first contact comprised the learning trials (under either explicit or implicit teaching instructions) followed by a two minute filler task.

The second contact started with a delayed free recall and delayed cued recall test relating to the list learned in the first contact, separated again by a filler task. Another filler task then preceded the learning trials for the second list (carried out under different teaching instructions). These were again followed by immediate free and cued recall tests also separated by a filler task.

The final contact started with a delayed free recall and delayed cued recall test relating to the list learned in the second contact, separated again by a filler task. The participant was then administered the Word Lists, the Tower Test and the WTAR, prior to providing some limited demographic information (age and date of birth, date and mechanism of injury, educational history). Table 2 shows a summary of the sequence of contacts for each participant.

Table 1. Participant demographic information/neuropsychological screening results

P No	Age Now	Gender	Cause of Injury	Years Since Injury	Word Lists Raw /Scaled		Tower Test Raw /Scaled/		WTAR
1	61	M	tbi	45	23	6	7	4	96
2	61	M	tbi	38	16	3	10	6	101
3	36	M	tbi	3	20	4	13	7	90
4	43	M	tbi	22	24	5	18	11	51
6	40	M	tbi	10	14	2	20	12	85
8	63	M	tbi	48	15	3	8	5	50
9	37	M	carbmon	10	27	6	13	7	66
13	58	M	tbi	6	28	9	19	12	104
14	37	M	tbi	17	26	6	17	10	99
15	56	M	stroke	9	22	5	19	12	89
16	50	M	tbi	47	29	8	10	6	-
17	64	F	tbi	11	9	1	7	4	80
19	63	F	tbi	8	39	15	13	8	106
20	53	M	hypox	53	25	6	10	6	-
21	52	M	stroke	2	26	7	7	4	103
22	45	F	tbi	39	7	1	16	10	74
23	42	M	tbi	3	25	6	22	14	74
24	61	F	tbi	14	28	9	17	11	117
25	48	M	stroke	4	33	11	20	12	106
26	58	F	stroke	11	27	8	11	7	78
27	32	M	tbi	11	25	6	16	9	104
28	54	M	stroke	7	23	5	19	12	-
29	28	M	neurosur	9	31	8	15	9	94
31	52	M	tbi	8	2	1	9	5	76
32	36	F	stroke	6	10	1	21	13	99
33	37	M	BT	4	31	8	17	10	108
34	53	F	stroke	16	10	1		1	99
35	49	M	stroke	6	26	7	20	12	101
36	55	M	tbi	35	23	6	17	11	113
37	44	M	BT	29	26	6	11	6	94
38	62	M	BT	3	15	3	7	4	101
39	52	M	BT	41	13	2	7	4	96
41	53	M	stroke	2	19	4	9	5	90
42	63	M	tbi	10	14	2	13	8	87

Note. Cells that contain a dash denote that a score was not obtained for this measure.
M = male; F = female; tbi = traumatic brain injury; carbmon = carbon monoxide poisoning; hypox = hypoxic brain injury; neurosur = brain injury caused by neurosurgical intervention; BT=cerebral tumour/cyst/abscess;

Table 2 – Summary of sequence of contacts for participants

Con-tact	Order 1	Order 2	Order 3	Order 4
1	Information/Consent Word learning List A (Explicit Instructions) Filler Test trial (Immediate Free recall) Filler Test trial (Immediate Cued recall) Questionnaire	Information/Consent Word learning List B (Explicit Instructions) Filler Test trial (Immediate free recall) Filler Test trial (Immediate cued recall) Questionnaire	Information/Consent Word learning List A (Implicit Instructions) Filler Test trial (Immediate free recall) Filler Test trial (Immediate cued recall) Questionnaire	Information/Consent Word learning List B (Implicit Instructions) Filler Test trial (Immediate Free recall) Filler Test trial (Immediate cued recall) Questionnaire
2	Test trial List A (Delayed free recall) Filler Test trial List A (Delayed cued recall) Filler Word learning List B (Implicit Instructions) Filler Test trial List B (Immediate free recall) Filler Test trial List B (Immediate cued recall) Questionnaire	Test trial List B (Delayed free recall) Filler Test trial List B (Delayed cued recall) Filler Word learning List A (Implicit Instructions) Filler Test trial List A (Immediate free recall) Filler Test trial List A (Immediate cued recall) Questionnaire	Test trial List A (Delayed free recall) Filler Test trial List A (Delayed cued recall) Filler Word learning List B (Explicit Instructions) Filler Test trial List B (Immediate free recall) Filler Test trial List B (Immediate cued recall) Questionnaire	Test trial List B (Delayed free recall) Filler Test trial List B (Delayed cued recall) Filler Word learning List A (Explicit Instructions) Filler Test trial List A (Immediate free recall) Filler Test trial List A (Immediate cued recall) Questionnaire
3	Test trial List B (Delayed free recall) Filler Test trial List B (Delayed cued recall) WTAR Tower Test WMS Word Lists	Test trial List A (Delayed free recall) Filler Test trial List A (Delayed cued recall) WTAR Tower Test WMS Word Lists	Test trial List B (Delayed free recall) Filler Test trial List B (Delayed cued recall) WTAR Tower Test WMS Word Lists	Test trial List A (Delayed free recall) Filler Test trial List A (Delayed cued recall) WTAR Tower Test WMS Word Lists

The full description of the procedures and instructions used in the implicit learning condition are given in Appendix 6. In some previous applications of implicit teaching instructions (e.g. Glisky, 1995) participants have simply been asked to look at the word stem and complete it with the first word that comes to mind. However, whilst this approach might be considered appropriate for those with severe memory impairments, this might have been problematic in the present study due to the inclusion of participants with less severe impairments, and it was therefore decided to be open with participants about the nature of the task. Participants were therefore told that they were going to be helped to learn a list of words but that the aim of the task was to get these words to stick in their memories without them trying to remember the words. They received repeated instructions not to try to remember the words but to see if the words came into their minds without trying. Examples were given to encourage the use of implicit memory, for instance participants were referred to the phenomenon where they see someone's face and try but are unable to remember the person's name, before later the name comes to them without actively trying to remember it. Participants were then asked to summarize the nature of the task to ensure it had been understood. Following presentation of the initial words (e.g. P L A T E), participants were presented with the same words in turn, initially with four letter cues (e.g. P L A T _) and asked to complete the word stem with the first word that came to mind. For each learning trial, the following instructions were used:

> "Now I'm now going to show you the same words but with some letters missing. The number of letters missing is indicated by the number of dashes after the letters. Please add the appropriate number of letters to make a complete word. As I show them to you, clear your mind and stay as relaxed as you can. And just say the first word that comes into your head when I show you the card. Don't try to remember what you saw before or what words were on the list. Don't make any effort. Just say the first thing that comes into your head. If nothing comes into your head, just tell me and we'll move on to the next word. Remember, its most important to follow my instructions not to try hard to remember the word but to see if it comes to you without trying".

If the target word was stated, it would be confirmed to the participant that the word had been shown to them previously, and the next (three letter) cue level would be used for that word in the next learning trial (e.g. P L A _ _). This procedure was repeated across the six trials with the cue level reducing by one letter following a correct response. If no errors were made on a particular item, then trials five and six would both comprise a one letter cue only (e.g. P _ _ _ _). On occasions where participants failed to state the target word (by error or omission), if they made an error (i.e. stated the wrong word) they would be told this was not a word they were shown, and (for both errors and omissions) they would be told “the word I showed you was _____” and shown the target word. In the subsequent learning trial, the cue level would be increased to the previous level. Participants were given ten seconds to provide their answer in all learning trials for both conditions. On completion of the final learning trial, participants would progress to immediate free and cued recall tests outlined above. Participants were given ten seconds to provide their answer in all learning trials for both conditions. On completion of the final learning trial, participants would progress to immediate free and cued recall tests outlined above.

The full description of the procedures and instructions used in the explicit learning condition are given in Appendix 7. Participants were instructed to try and remember each word shown to them. They were encouraged to use strategies to help them to remember the words and provided with examples of such strategies. They were repeatedly instructed to try as hard as they could to remember each word during the learning trials. Following presentation of the initial words, participants were presented with the same words in turn, initially with four letter cues and asked to think back to the words learned earlier and try to remember that word. For each learning trial, the following instructions were used:

> "Now I'm now going to show you the same words again but with some letters missing. Please think back to the list you learned before and try to remember what the word is. Please try as hard as you can to remember the word".

If the target word was stated they were told it was correct, and the next cue level would be used for that word in the next learning trial, with the cue level gradually reducing with correct responses across the learning trials. If participants failed to state the target word (by error or omission), if relevant they would be told this word was 'incorrect'; told "the correct word is ____"; and shown the target word.

At the end of sessions one and two, a brief questionnaire was administered to all participants that related to the approach they had used during the learning trials. The questionnaire was used in an attempt to assess whether participants had used explicit strategies under implicit learning conditions and vice versa, due to the difficulties obtaining pure measures of implicit and explicit memory (Jacoby, 1991; Schacter, Bowers & Booker, 1989). A frequent concern, albeit one that is difficult to guard against, is that during implicit test trials participants may attempt to improve their performance with explicit memory efforts. This is most likely to occur in test trials where participants come to suspect that their memory is being surreptitiously assessed, and in the present study it was hoped that being honest with participants about the nature of the implicit learning task would reduce the likelihood of explicit memory being used during the implicit test phase. Nevertheless this remained a possibility, which was explored in the questionnaires. Likewise it is of course possible that participants will use implicit recall strategies when instructed to rely on explicit memory, and this possibility was explored in the questionnaires. The content of the questionnaires is set out in the protocols at Appendix 6/7.

RESULTS

Introduction

The total and mean scores for each of the four recall measures are shown in Table 3. It can be seen that the scores for immediate cued recall and delayed free recall were subject to ceiling and floor effects respectively. These measures were therefore excluded from the main analysis and hereafter have not been reported in the results. Likewise, to maintain greater simplicity and brevity, those analyses that were deemed unimportant for the interpretation of the results have not been reported in full.

Table 3 – Scores by Recall Measure

	Total Score*	Mean Score*	Range	Standard Deviation
Immediate free recall	328	9.647	0-19	2.862
Immediate cued recall	575	16.912	0-20	2.618
Delayed free recall	92	2.706	0-12	2.051
Delayed cued recall	344	10.118	0-16	2.742

Maximum total score for each measure = 680, Maximum possible individual score for each measure = 20

Some order and list effects were also noted. These have not been reported in full in order to simplify the reporting of the results. The mean scores by list and order are set out in full in Appendix 8. Of particular note is that those participants who learned under explicit teaching instructions first learned significantly better under explicit instructions (mean score = 24.67) than under implicit teaching instructions (mean score 16.22), whereas the scores of those who learned first under implicit instructions (mean score = 18.13) learned equally well under implicit and explicit teaching instructions (mean score 18.88). Similarly, the mean scores for both teaching conditions were higher for those who learned List B first than those who learned List A first. For this reason, it was decided to include order as a between-subject variable in the main data analysis.

The study's hypothesis was that the degree of participants' memory impairment will impact on their performance under different teaching instructions. Specifically it was hypothesized that those with less severe memory impairment would show a greater improvement under explicit instructions (relative to implicit instructions) than those with more severe memory impairment. To this end, according to their raw scores on the WMS-III Word Lists participants were divided into two groups of 17 (higher scorers and lower scorers). A role was also suggested both for participants' level of executive functioning and for item difficulty; the latter being indexed by the number of errors made by participants during the learning trials and being roughly equivalent to the difficulty ratings used in the design phase based on the study by Jacoby (1998). The number of within and between subject factors increased the likelihood of extreme complexity within the analysis and confusing results. Item difficulty was incorporated into the analysis by dividing ranking the words in each list according to the number of errors made during the learning trials and categorizing the five those with most errors as 'hard' and the five with fewest errors as 'easy'. These ratings were roughly equivalent to the difficulty ratings used in the design phase based on the study by Jacoby (1998). Executive functioning was incorporated into the analysis by ranking participants according to their raw scores on the Tower Test and divided into two groups, one of 16 (higher scorers) and one of 18 (lower scorers). Howell (2002) discusses the difficulties associated with complex data analyses and recommends a series of less complex analyses. A decision was therefore made to first analyse the data without reference to participants' executive functioning, and thereafter to give consideration to this variable. The different steps involved in the data analysis are set out in Table 4. It should be noted that the sequence of analysis was identical for both measures (immediate free recall and delayed cued recall).

Table 4 – Steps of Data Analysis – Immediate Free Recall and Delayed Cued Recall

	Within Groups	Between Groups
Step 1 Main Analysis	teaching instructions (implicit/explicit) item difficulty (easy/hard)	severity of memory impairment (higher/lower scores) list order (list A/list B)
Step 2: Separate Analyses for Easy Words and Hard Words	teaching instructions (implicit/explicit)	severity of memory impairment(higher/lower scores) list order (list A/list B)
Step 3: Separate Analyses for Executive Functioning (higher/lower scores) (repeating steps 1, 2	teaching instructions (implicit/explicit) item difficulty (easy/hard)	severity of memory impairment (higher/lower scores) list order (list A/list B)
Step 4 (for cued delayed recall only): Separate analyses for word difficulty (easy vs hard) and level of memory impairment (higher vs lower)	teaching instructions (implicit/explicit)	severity of executive impairment (higher/lower scores)

All data were checked for their suitability for parametric analysis. This was effected by examining for outliers, whether the distributions departed significantly from normal and by checking Mauchly's Test of Sphericity for within-subjects effects and Levene's Test of

Equality of Error Variances for between-subject effects. These were satisfactory for all analyses.

Immediate Free Recall Data

The mean scores and effects of this data for Step 1 of the analysis are listed in Tables 5/5a/5b.

Table 5 – Immediate Free Recall: Step 1

Within Subject Effects	F	sig
Implicit/Explicit	8.676	.007
Easy/Hard	3.559	.070
Implicit/Explicit x Memory Group	.292	.594
Implicit/Explicit x Memory Group x Easy/Hard	8.686	.007
Between Subject Effects	F	sig
Memory Group	37.616	.000

Table 5a – Immediate Free Recall – Mean Scores by Learning Condition

N=34	Min Score	Max Score	Mean	SD*
Implicit	0	9	4.177	2.969
Explicit	0	10	5.477	2.755

- **SD = Standard Deviation**

Table 5b – Immediate Free Recall – Mean Scores by Item Difficulty

N=34	Min Score	Max Score	Mean	SD*
Easy Items	0	9	4.471	2.744
Hard Items	0	10	5.147	2.765

It can be seen that the teaching instruction effect was highly significant in favour of explicit teaching instructions. There was an effect approaching significance for item difficulty, meaning that participants learned the harder words better than the easy words. There was also a highly significant 'memory group' effect, thus not surprisingly those with less severe memory impairments did better overall than those with more severe impairments.

In terms of the interaction effects it can be seen that there was no significant interaction between teaching instructions and memory group. Thus there was no support for the hypothesis that those with less severe memory impairments would show a greater improvement under explicit instructions (relative to implicit instructions) than those with more severe memory impairment. However, when item difficulty was also taken into account, there was a highly significant three way interaction between teaching instructions, item difficulty and memory group.

Given the impact of item difficulty, further independent analysis was carried out for both easy and hard words. These mean scores and main effects measure are reported in Tables 6/6a and 7/7a. For both easy and hard words, the teaching instruction effect was highly significant. However, whilst the interaction effect between teaching instructions and memory group was significant for easy words, this was not maintained for the hard words.

Table 6 – Immediate Free Recall: Effects (Easy Words)

Within Subject Effects	F	sig
Implicit/Explicit	5.571	.026
Implicit/Explicit x Memory Group	5.206	.031

Table 6a – Immediate Free Recall: – Mean Scores by Learning Condition (Easy Words)

N=34	Min Score	Max Score	Mean	SD*
Implicit	0	5	1.912	1.464
Explicit	0	5	2.559	1.709

*** SD = Standard Deviation**

Table 7 – Immediate Free Recall: Effects (Hard Words)

Within Subject Effects	F	sig
Implicit/Explicit	5.200	.031
Implicit/Explicit x Memory Group	1.872	.183

Table 7a – Immediate Free Recall: – Mean Scores by Learning Condition (Hard Words)

N=34	Min Score	Max Score	Mean	SD*
Implicit	0	5	2.265	1.781
Explicit	0	5	2.882	1.387

*** SD = Standard Deviation**

For this data set therefore, there was some support for the hypothesis that those with less severe memory impairments would show a greater improvement under explicit instructions (relative to implicit instructions) than those with more severe memory impairment. However this applied for the easier and not the harder items. This distinction goes some way to explaining the lack of significant interaction between teaching instructions and memory group in the main effects for this data set detailed in Table 5.

The performance of participants is set out graphically in Figures 3 and 4. For the easy words (Figure 3), in line with the hypothesis, it can be seen that those with less severe memory impairments (Memory Group 2.00) demonstrate a marked improvement under explicit (in comparison to implicit) teaching instructions (explicit boost). Those with more severe impairments (Memory Group 1.00) perform at the same level regardless of teaching instructions. For the hard words (Figure 4), a less marked explicit boost is apparent for those with less severe memory impairments (Memory Group 2.00), whilst those with more severe impairments (Memory Group 1.00) demonstrate a marked improvement under explicit teaching instructions (explicit boost). Of particular note is the difference in mean scores according to item difficulty for those with more severe memory impairments (Memory Group 1.00) under explicit teaching instructions. The mean score for easy words was 1.294 whilst the mean score for hard words was 2.118.

Figure 3 – Immediate Free Recall: Easy Words

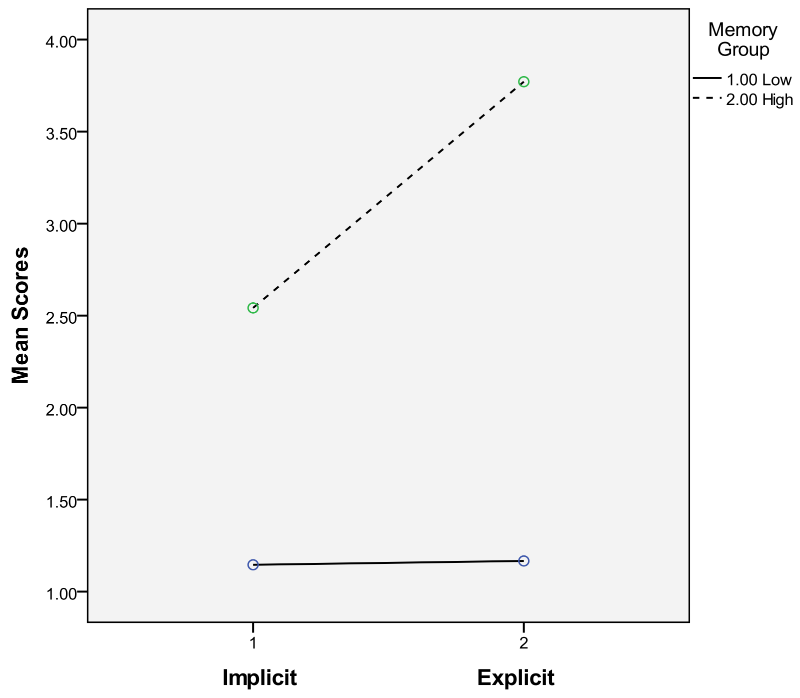
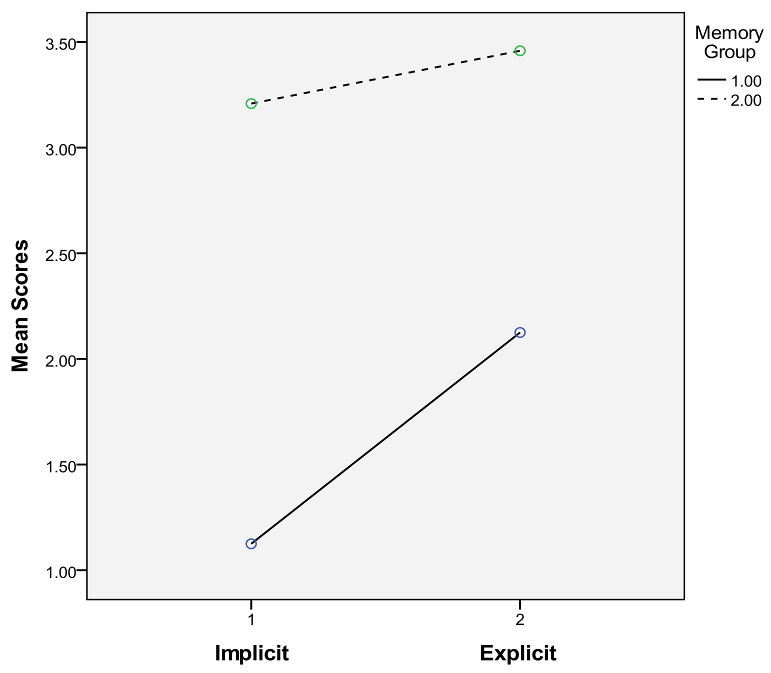


Figure 4 – Immediate Free Recall: Hard Words



Steps 1 and 2 of the analysis were then repeated separately for those with higher and lower scores on the Tower Test (executive functioning). Both groups showed a similar pattern to each other and to the data set for the overall group already described. No effect of executive functioning was apparent for the free recall data. These results are therefore not reported, but can be found in Appendix 9.

Delayed Cued Recall Data

The mean scores and important effects of the data for this measure are listed in Table 8/8a/8b.

Table 8 – Delayed Cued Recall: Step 1

Within Subject Effects	F	sig
Implicit/Explicit	3.513	.072
Easy/Hard	9.915	.005
Implicit/Explicit x Memory Group	4.826	.037
Implicit/Explicit x Memory Group x Easy/Hard	.001	.971
Between Subject Effects	F	sig
Memory Group	15.699	.001

Table 8a – Delayed Cued Recall – Mean Scores by Learning Condition

N=34	Min Score	Max Score	Mean	SD*
Implicit	0	9	4.559	2.665
Explicit	0	10	5.559	2.820

- **SD = Standard Deviation**

Table 8b – Delayed Cued Recall – Mean Scores by Item Difficulty

N=34	Min Score	Max Score	Mean	SD*
Easy Items	0	9	5.559	2.363
Hard Items	0	8	4.500	2.502

- **SD = Standard Deviation**

It can be seen that there was an effect approaching significance for teaching instructions (in favour of explicit teaching instructions). There was a highly significant effect for item difficulty, although on this measure participants recalled the easier words better than the harder words. There was also a highly significant 'memory group' effect, so as would be expected those with less severe memory impairments again did better overall than those with more severe impairments. In terms of the interaction effects there was a significant interaction between teaching instructions and memory group, which provides further support for the hypothesis that those with less severe memory impairments would show a greater improvement under explicit instructions (relative to implicit instructions) than those with more severe memory impairment. There was no interaction effect between teaching instructions, item difficulty and memory group.

Further independent analysis was carried out for both easy and hard words. Again, this analysis is not reported in detail, as both easy and hard words showed a similar pattern. This is set out graphically in Figures 5 and 6. Please refer to Appendix 10 for scores in tabular format.

Figure 5 – Delayed Cued Recall: Easy Words

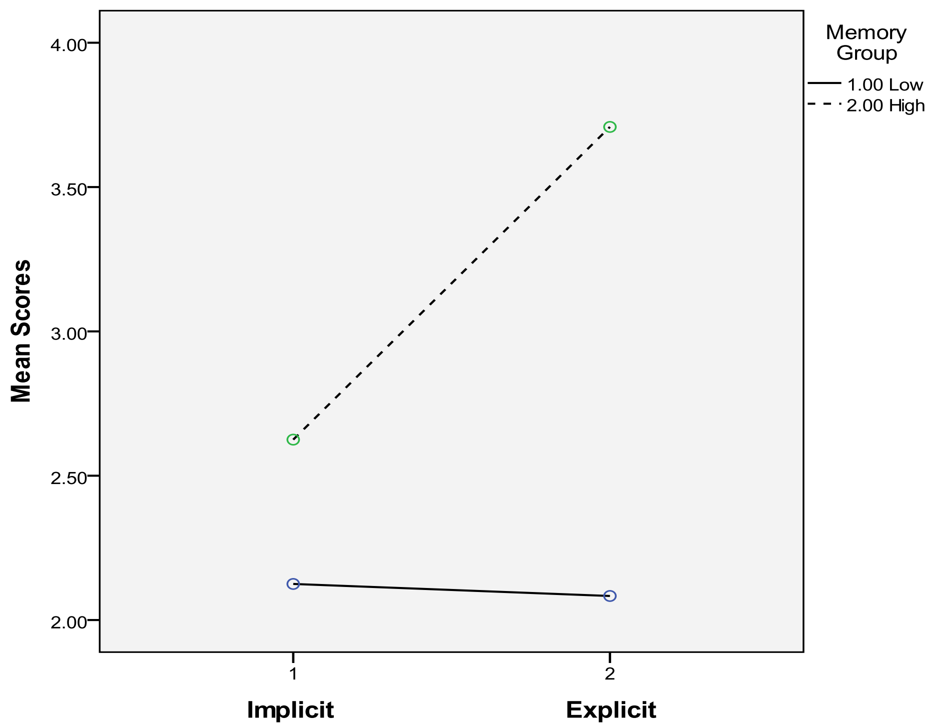
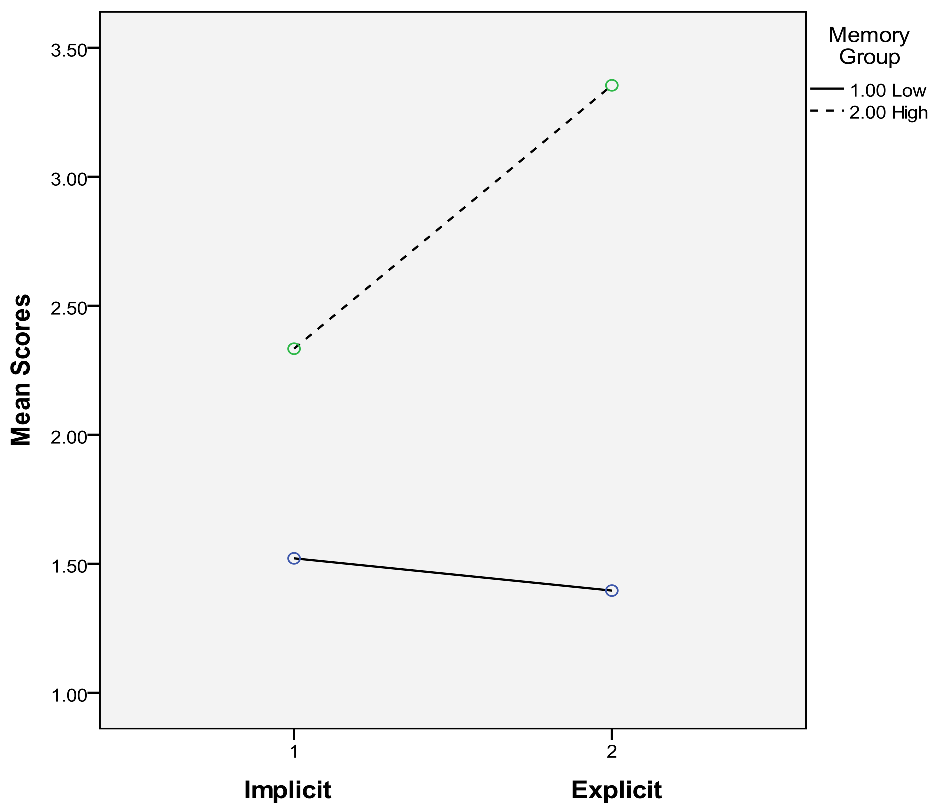


Figure 6 – Delayed Cued Recall: Hard Words



As with the data for the immediate free recall measure, the next phase of the analysis involved the introduction of executive functioning. The same analysis was carried out for the high and low executive functioning groups respectively. The mean scores and main effects of the data for this measure are listed in Tables 9/9a/9b and 10/10a/10b.

Table 9 – Delayed Cued Recall: Main Effects (Low Executive Functioning Group)

Within Subject Effects	F	sig
Implicit/Explicit	.663	.433
Easy/Hard	1.987	.186
Implicit/Explicit x Memory Group	3.422	.091
Implicit/Explicit x Memory Group x Easy/Hard	3.346	.061
Between Subject Effects	F	sig
Memory Group	5.808	.035

Table 9a – Delayed Cued Recall – Mean Scores by Learning Condition (Low Executive Functioning Group)

N=18	Min Score	Max Score	Mean	SD*
Implicit	0	9	3.778	3.001
Explicit	0	8	4.278	2.607

- **SD = Standard Deviation**

Table 9b – Delayed Cued Recall – Mean Scores by Item Difficulty (Low Executive Functioning Group)

N=18	Min Score	Max Score	Mean	SD*
Easy Items	0	8	4.389	2.145
Hard Items	0	8	3.611	2.682

- **SD = Standard Deviation**

Table 10 – Delayed Cued Recall: Main Effects (High Executive Functioning Group)

Within Subject Effects	F	sig
Implicit/Explicit	9.109	.015
Easy/Hard	6.712	.029
Implicit/Explicit x Memory Group	1.078	.326
Implicit/Explicit x Memory Group x Easy/Hard	26.136	.001
Between Subject Effects	F	sig
Memory Group	1.794	.213

Table 10a – Delayed Cued Recall – Mean Scores by Learning Condition (High Executive Functioning Group)

N=16	Min Score	Max Score	Mean	SD*
Implicit	2	9	5.438	1.965
Explicit	3	10	7.000	2.366

- **SD = Standard Deviation**

Table 10b – Delayed Cued Recall – Mean Scores by Item Difficulty (High Executive Functioning Group)

N=16	Min Score	Max Score	Mean	SD*
Easy Items	4	9	6.875	1.892
Hard Items	2	9	5.500	1.897

- **SD = Standard Deviation**

There were significant main effects for item difficulty and teaching instructions in the high executive functioning group only. There was a significant ‘memory group’ effect in the low executive functioning group, which was lost for the high group, suggesting that those with higher levels of executive functioning the effect of memory was less marked. The interactions between teaching instructions and memory group (in line with the hypothesis) and between teaching instructions, memory group and item difficulty both approached significance in the low group. However, although there was no significant interaction between teaching instructions and memory group in the high group, the interaction and between teaching instructions and memory group was highly significant when item difficulty was introduced.

Further analysis was again carried out for both easy and hard words. These mean scores and main effects measure are reported in Tables 11 – 14a. For the low functioning group, there was a significant interaction between teaching instructions and memory group for hard words only. For the high functioning group, there was a highly significant teaching instructions effect for both easy and hard words and a significant interaction between teaching instructions (in line with the hypothesis) for the easy words only.

Table 11 – Delayed Cued Recall: Effects (Low Executive Function Group, Easy Words)

Within Subject Effects	F	sig
Implicit/Explicit	.704	.419
Implicit/Explicit x Memory Group	.736	.409

Table 11a – Delayed Cued Recall: Means (Low Executive Function Group, Easy Words)

N=18	Min Score	Max Score	Mean	SD*
Implicit	0	5	2.000	1.608
Explicit	0	4	2.389	1.289

Table 12 – Delayed Cued Recall: Effects (Low Executive Function Group, Hard Words)

Within Subject Effects	F	sig
Implicit/Explicit	.452	.515
Implicit/Explicit x Memory Group	8.767	.013

Table 12a – Delayed Cued Recall: Means (Low Executive Function Group, Hard Words)

N=18	Min Score	Max Score	Mean	SD*
Implicit	0	5	1.778	1.592
Explicit	0	5	1.833	1.723

Table 13 – Delayed Cued Recall: Effects (High Executive Function Group, Easy Words)

Within Subject Effects	F	sig
Implicit/Explicit	6.198	.034
Implicit/Explicit x Memory Group	7.800	.021

Table 13a – Delayed Cued Recall: Means (High Executive Function Group, Easy Words)

N=16	Min Score	Max Score	Mean	SD*
Implicit	0	5	3.125	1.360
Explicit	1	5	3.750	1.238

Table 14 – Delayed Cued Recall: Effects (High Executive Function Group, Hard Words)

Within Subject Effects	F	sig
Implicit/Explicit	10.113	.011
Implicit/Explicit x Memory Group	.482	.505

Table 14a – Delayed Cued Recall: Means (High Executive Function Group, Hard Words)

N=16	Min Score	Max Score	Mean	SD*
Implicit	0	4	2.25	1.000
Explicit	1	5	3.25	1.390

The performance of participants is set out graphically in Figures 7 – 10. For the easy words (Figures 7/9), in line with the hypothesis, it can be seen that those in both groups with less severe memory impairments (Memory Group 2.00) demonstrate marked improvements under explicit (in comparison to implicit) teaching instructions (explicit boost), whilst those with more severe impairments (Memory Group 1.00) perform at a similar level regardless of teaching instructions. However for the hard words (Figures 8/10), whilst an explicit boost is again evident for the high executive function group (regardless of level of memory impairment), this benefit is lost for the low executive function group with more severe memory impairment. This is the only combination of variables where performance in the implicit condition is noticeably superior to performance under explicit conditions, however this difference was not statistically significant (t = -1.765, df = 20, p = .108). It therefore appears that for more difficult items, those with better executive functioning are able to benefit from a boost from explicit teaching instructions regardless of their level of memory impairment, however for those with poorer executive functioning and more severe memory impairments, this trend may be reversed in that explicit (in comparison with implicit) teaching instructions may adversely affect their performance.

Figure 7 – Delayed Cued Recall: Easy Words (Low Executive Function Group)

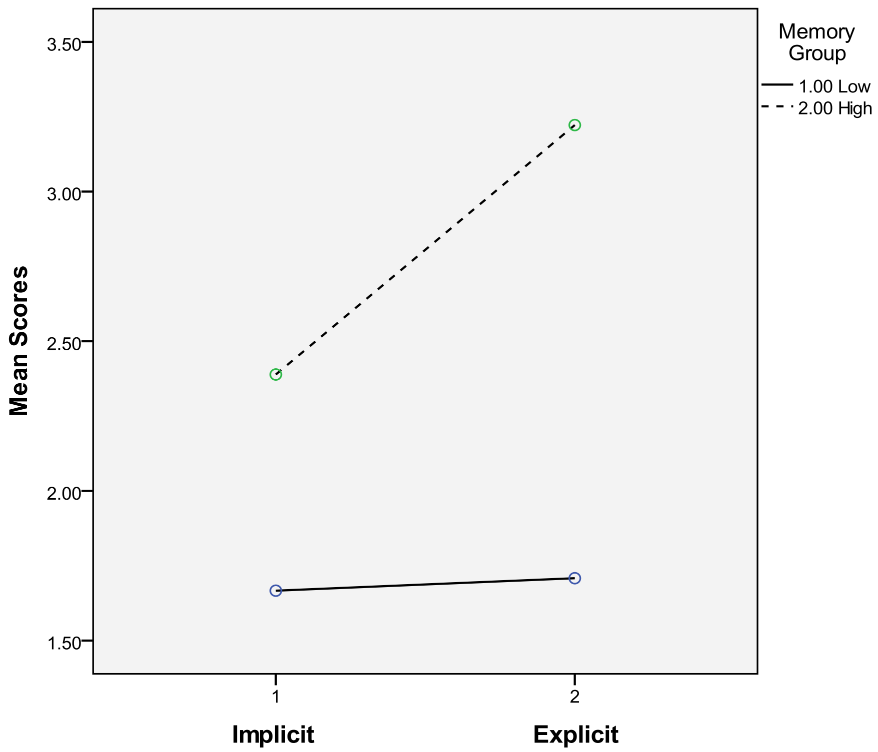


Figure 8 – Delayed Cued Recall: Hard Words (Low Executive Function Group)

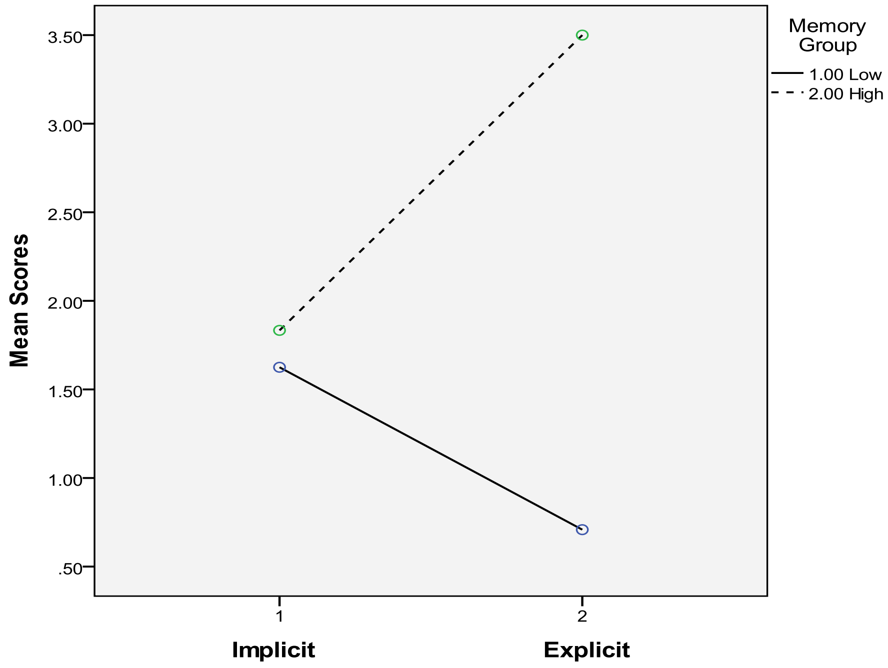


Figure 9 – Delayed Cued Recall: Easy Words (High Executive Function Group)

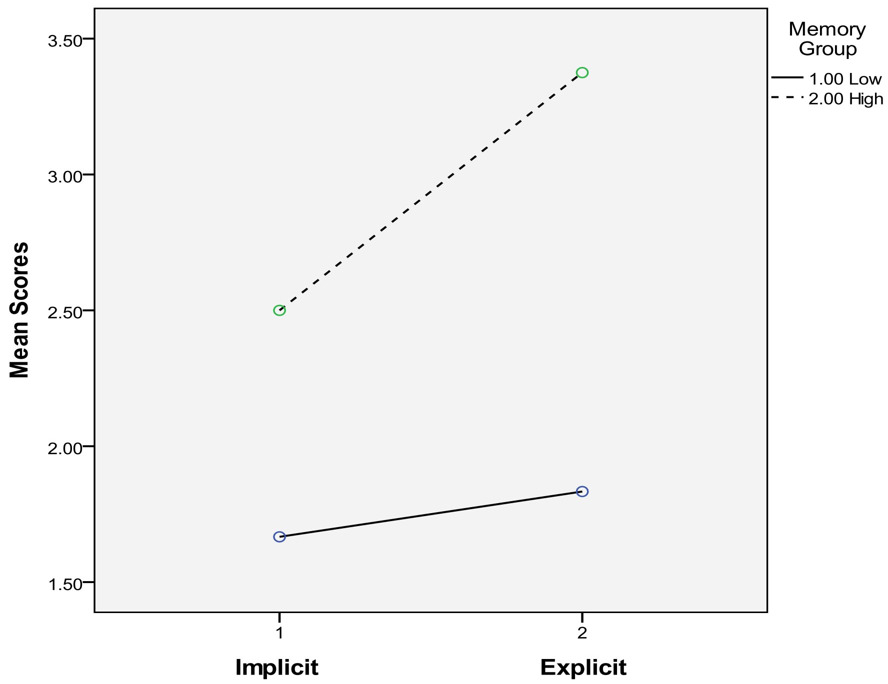
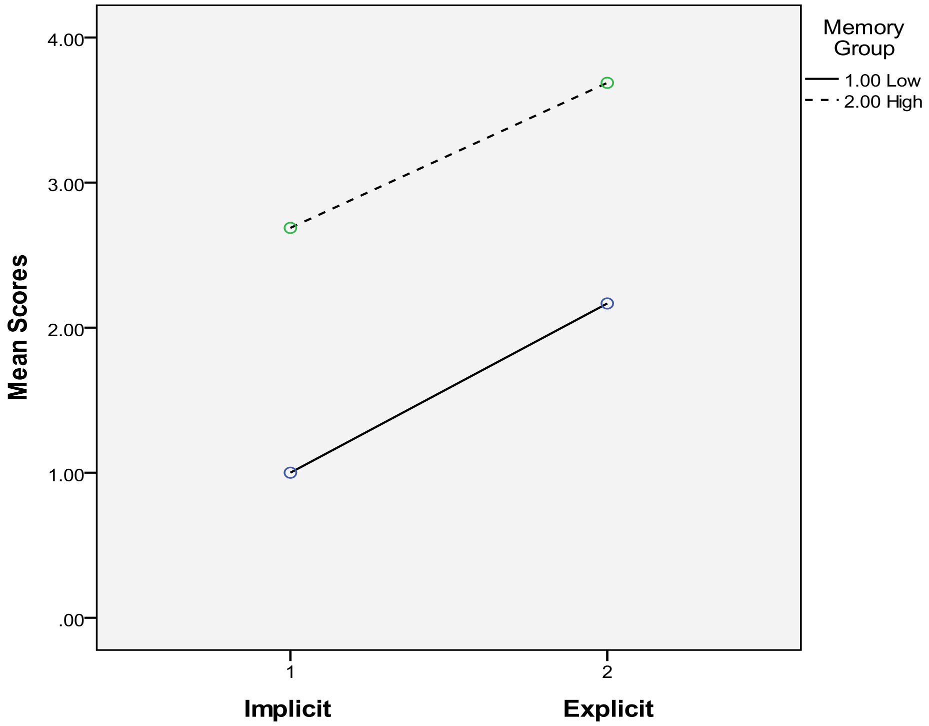


Figure 10 – Delayed Cued Recall: Hard Words (High Executive Function Group)



To explore further the difference between these four groups (higher executive + higher memory; higher executive + lower memory; lower executive + higher memory; lower executive + lower memory), four additional analyses were carried out on the delayed cued recall data which examined the interaction between instructional condition and level of executive impairment for each combination of word difficulty and level of memory impairment. For the easy words, there was no significant instruction-x-executive impairment interaction for either the group with poorer memories (F (1, 64) = .05; p = .857) or the group with better memories (F(1,64) = 1.00; p = .340). For the hard words, there was no significant interaction for the group with better memories (F(1,64) = .128); p = .728), however this interaction was significant for the group with poorer memories (F(1,64) = 10.143; p = .010). Thus, considering just those with more impaired memory, those with greater impairments of executive functioning failed to benefit from explicit instructions in learning the hard words to the same extent as those with less impaired executive functioning; and, indeed, as noted earlier, showed a non-significant trend to performing worse under explicit instructions with the hard words (t = -1.765, df = 20, p = .108).

Results of questionnaire

A questionnaire was administered (see Appendices 6/7) to participants regarding their approach to the learning trials. Two participants who stated clearly they had used explicit processes despite being given implicit teaching instructions were subsequently excluded from the study. The responses of all 34 respondents who completed the study were such that they remained in the study. It should be noted however that whilst some participants clearly indicated they had followed the instructions appropriately, others were unclear, stating for example “I just remembered”. Others reported following the teaching instructions but it is unclear how consistently they did so. Several participants inadvertently indicated either the occasional use of explicit processes under implicit instructions, for example by uttering semantic links out loud (e.g. duck-quack), whilst others indicated the occasional use of implicit processes under explicit instructions (e.g. stating “I can’t remember so I’ll say whatever comes to mind …”).

DISCUSSION

The study’s hypothesis was that those participants with less severe memory impairment would show a greater improvement under explicit instructions (relative to implicit instructions) than those with more severe memory impairment. A role was also suggested both for participants' level of executive functioning and for item difficulty. However, no specific hypothesis was established in respect of these variables.

For the immediate free recall data, there was significant support for the hypothesis but only when item difficulty was taken into account, as this advantage was only evident for easier items. Participants' level of executive functioning did not impact significantly on this trend. For the delayed cued recall data, there was a significant interaction between teaching instructions and severity of memory impairment (in line with the hypothesis), regardless of item difficulty. When controlling for executive functioning, this general pattern was evident the easy words only. For the hard words, those participants with better executive functioning gained a boost from explicit instructions regardless of level of memory impairment, however for those with poorer executive functioning this pattern was not evident in that the performance of those with more severe memory impairments actually deteriorated under explicit instructions, albeit this difference was not significant. Interestingly, those in the low memory group showed an explicit boost for hard words on the immediate free recall measure regardless of the level of executive functioning (Figure 4). On the delayed cued recall measure one week later, those in the low memory group with higher executive functioning maintained this explicit boost for hard words (Figure 10). However those in the low memory group with lower executive functioning had lost this boost and actually performed worse under explicit instructions compared to implicit instructions (Figure 8). Although this difference was not significant ($p=.108$), it is worth noting that the statistical power of this test was low as it compared only eleven against seven participants.

Severity of memory impairment

Extensive support for the study's hypothesis that those with less severe memory impairments would show more benefit from explicit instructions than those with more severe impairments was found across these results. The results concur with those obtained in Riley and Heaton (2000) and Riley et al. (2004). The results of these studies suggested that those with less severe impairments benefit more from explicit teaching instructions and from a reduced level of assistance (in relation to the more severely impaired) when using the MVC, provided the teaching trial recall had been effortful. It can be concluded that those with less severe memory impairments benefit from instructions designed to encourage the use of their residual explicit memory.

Item difficulty

There was also some limited evidence to support the claims made in the introduction about the role of item difficulty in recall performance. Item difficulty was defined with reference to the number of errors made during the teaching trials. It was argued that errors provide some indication of the degree of effort involved in the teaching trial recall during MVC; that more effort (provided that it is reasonably successful) will lead to better recall; and that therefore a modest, but not excessive, number of errors may be associated with better recall. [See pp. 50-51 above]. The results of the present study provide some limited support for this argument. The hard items resulted in better immediate free recall than the easy items, although the difference only approximated significance (p=.07). Again, this is in line with the findings of Riley and Heaton (2000) and Riley et al. (2004) who found that the number of training errors was positively correlated with recall and that effortful recall attempts were beneficial provided an appropriate balance between effort and error reduction could be achieved. However, this advantage for hard items disappeared on the delayed cued recall test, in which this pattern relating to item difficulty was reversed, and items associated with a greater number of errors during the training trial recall were recalled less well. A combination of factors may explain this difference. It may be at least partly related to the impact of errors in the longer term leading to deterioration in performance for those with poorer executive functioning. This is discussed in greater detail below. However, this does not account for the performance of those with better executive functioning on the delayed cued recall test. A further possible explanation for this pattern reversal may be related to differences between tests of free and cued recall. Item difficulty (as defined by the number of training trial errors) corresponded closely to data in the study by Jacoby (1991) regarding the reduced probability of coming up with this word when participants were asked to say the first word that came to mind to complete a word stem. In other words, participants were less likely to correctly identify the more difficult items when given these instructions. Thus it seems probable in the cued recall test participants benefitted from the additional cue provided by the first two letters to a greater extent for the easier items than for the harder items. Other studies (e.g. Mimura & Komatsu, 2010) have also identified a benefit for effort on a free but not a cued recall test. In the Mimura and Komatsu (2010) study, it was concluded that the benefit from effort arises in the absence of environmental support (such as that provided by cued recall) and the task therefore requires participants to initiate retrieval themselves (as in free recall).

Executive functioning

The present study also addressed the role of executive functioning difficulties in determining the response of the participants to the respective teaching conditions. Evidence was identified which suggested this did impact. Whereas those in the low memory group showed an explicit boost for hard words on immediate recall regardless of the level of executive functioning; on the delayed recall a week later, the explicit boost for the harder words was maintained for those in the low memory group but with higher levels of executive functioning. However, for those with both more severe memory impairments and lower levels of executive functioning there was no such boost. Indeed this group of participants actually performed worse when given explicit teaching instructions than when given implicit instructions, albeit this difference was not statistically significant. The reasons underlying this finding are far from clear. It has been argued (e.g. Pitel et al., 2006; Baddeley & Wilson, 1994) that error monitoring and correction depend not only on episodic memory but also on executive functioning: Executive functioning encompasses the ability to recognize and inhibit errorful responses in favour of correct responses. It also encompasses the ability to generate effective strategies for dealing with errors. In the present study, the effectiveness of participants' response to making errors appeared to deteriorate at different rates for the high and low executive groups. This may be due to the possibility that both groups made similar kinds of responses to errors in the short term, but for some reason the effectiveness of these responses showed greater deterioration over time in the lower executive functioning group. One possible explanation may be that all participants were able to recognize and correct errors for the immediate recall test, but that after a week-long delay, those in the lower levels of executive functioning were not able to recognise errors to the same degree or to distinguish between the competing memory traces for errors and correct responses during learning trials.

Alternatively, it is possible each group responded differently to making errors. Those with higher levels of executive functioning may have derived some additional benefit from making errors because it prompted them to generate and employ some strategy to ensure that they did not make that error again. By contrast, those in the lower executive group may not have generated and used such strategies. Employing strategic responses to errors may have enabled those with higher levels of executive functioning to sustain the boost that they enjoyed for the responses to items on which they made more errors during the training trials. Whatever the explanation, these results add to the small but growing body of evidence (e.g. Fillingham, Sage & Lambon-Ralph, 2006) that level of executive functioning should be taken into account when planning cognitive rehabilitation interventions.

Limitations of the study

This study attempted to ensure that participants relied differentially on implicit or explicit memory processes according to the condition in which they were participating. In a previous study (Page et al., 2006), which used both implicit and explicit instructions, no teaching instructions effect was found. Given this study made no hypothesis regarding the differential use of instructions, it is possible that little attention was given to this issue, and the brief instructions given to participants were not sufficiently clear and/or detailed to lead to an effect. Of interest however is that it was questioned to what extent participants were genuinely following the instructions provided. Given the range of responses given by participants to the questionnaires regarding their approach to the experimental task under different teaching instructions, it is uncertain whether all participants understood and followed all teaching these appropriately, even though efforts were made to maximise their understanding, particularly in the implicit condition. Indeed, the time taken to ensure participant understanding throughout the implicit teaching condition increased the time taken in this condition by almost 50%, which may itself have impacted on the results. One possibility is that these instructions were too long and complex for some participants, arguably in particular those with more severe memory impairment and lower levels of executive functioning. However, even if this were the case, and participants were confused by the task, it is likely that they would have relied on implicit memory in what would have amounted to a straightforward stem completion task in the delayed test trial.

This like many other studies (e.g. Riley and Heaton, 2000; Evans et al., 2000; Bier et al., 2008) relates its conclusions to severity of memory impairment, yet severity is inconsistently defined across studies. Some studies have used the Rivermead Behavioural Memory Test (RBMT; Wilson, Cockburn & Baddeley, 1985) to define severity of impairment, with severe impairment being classified as a screening score of 3 or below, whilst others have used a variety of measures, including subtests and index scores from the WMS-III and its predecessor the Wechsler Memory Scale-Revised (WMS-R; Wechsler, 1987). Tailby and Haslam (2003) classified participants as moderately impaired if they scored between 70 and 89 on the WMS-III Verbal Memory Index, yet scores at the upper end of this classification would place them in the average range. In addition, some studies (e.g. Riley & Heaton, 2000) have included in their sample participants with no apparent memory impairment. In this study too, participants were divided into groups, based on the severity of their memory impairment (and of their executive functioning ability). The basis of their classification into those with more and less severe memory impairments (performance on the WMS-III Word Lists) was again different from other studies. The question of classification is beyond the scope of this study, however it is important to note that without consistency and clarity of definition across studies, clinicians will have greater difficulty selecting appropriately targeted interventions.

As previously reported, this study employed the WMS-III Word Lists (Wechsler, 1997) and the D-KEFS Tower Test (Delis et al, 2001) as measures of participants' memory and executive functioning. Memory and executive functioning are complex phenomena with multiple components, and the issue therefore arises of the validity of classifying participants' functioning across these cognitive domains on the basis of only one measure. It would have been preferable to assess participants using a number of different measures designed to tap different aspects of each participant's memory and executive functioning. This would have facilitated analysis and improved understanding of the relationship between participants' performance and specific aspects of their cognitive profile. Unfortunately, time constraints prevented more extensive neuropsychological assessment of participants in this study.

It is also possible that extensive neuropsychological assessment may have led to a greater number of participants disengaging from a study in which the attrition rate (almost 20%) was a cause for concern. For four of the eight participants who dropped out were the reasons for dropping out were unclear. One possible explanation for their drop out is their level of cognitive impairment was such that they were either unable to understand the instructions or feared being unable to cope with the experimental task. Either way, it is arguable that the remaining sample may be biased. Alternatively, it is possible that these participants did not wish to continue as they became bored by the task, particularly in the implicit condition where efforts to ensure participants' compliance with implicit teaching instructions led to a marked increase in the time taken in this condition. Whilst some participants indicated that they enjoyed the experimental tasks, others clearly did not, and there may well have been occasions where for those that did continue this affected their level of engagement. A lack of engagement might have impacted on performance in this task in a variety of ways, for example participants may not remained motivated to try their best, there may have been greater fluctuations in their levels of attention or they may have resorted to using implicit strategies under explicit teaching instructions. Any reduction in the level of participants' engagement raises questions about the validity of the results.

This study used word list learning as the experimental task, the ecological validity of which has often been questioned (e.g. Higbee et al., 1990). Whilst using word lists has the added benefit of enhancing experimental control, it comes at the cost of reduced ecological validity. Indeed, many studies investigating the use of instructional methods in memory rehabilitation have either used word list learning and/or lacked ecological validity (Ehlhardt et al., 2008). This review identified some convincing evidence for the use of systematic instruction in memory rehabilitation, however it also commented on the lack of clarity in the design and execution of these methods. It also highlighted the importance of selecting ecologically valid targets for new learning and the importance of variation to avoid hyperspecificity of learning and to enhance generalisation. The absence of both these features from this study can be considered as a weakness, notwithstanding the gains of enhanced levels of control.

Clinical and research implications

The results of this study clearly indicate that when using the MVC teaching instructions that encourage the use of residual explicit memory processes are preferable for people with less severe memory impairments. It also indicated that such instructions are also preferable for those with more severe impairments, provided their executive functioning is relatively intact.

For those with more severe memory impairments and lower levels of executive functioning the implications are less clear. It may be that teaching instructions that encourage the use of implicit memory processes may be preferable for this group. Alternatively, it may be that explicit teaching instructions should be considered, provided additional care is taken to avoid errors being made. Either way, it is vital that consideration of an individual's neuropsychological profile, in particular the extent of any impairments of executive functioning, is taken into account when planning this type of memory rehabilitation intervention.

This study has also pointed to the importance of task related factors when planning such interventions. These include task difficulty and the availability or otherwise of cues to prompt retrieval. Ehlhardt et al. (2008) remind us of the importance of selecting ecologically valid tasks for intervention, the absence of which from this study serves as a valuable reminder of the importance of additional interpersonal factors such as motivation and engagement with the learning material. Such factors have been asserted as being crucial in helping memories to last (Bradley, Kapur & Evans, 2003).

It has previously been asserted (Riley & Heaton, 2000) that a focus on the evaluation and use of one method over another is misplaced without consideration of all the relevant circumstances. These circumstances include both participant and task characteristics. A more appropriate focus for future research given the heterogeneity of cognitive profiles both within and across clinical groups is an evaluation of what are the most effective strategies for learning specific skills and information and how do these interact with specific aspects of the client's neuropsychological profile.

The present study established a greater role for reliance on residual explicit memory processes, for both the more and the less severely memory impaired. However, given the clear deterioration in performance over time for those with more severe memory impairments and lower levels of executive functioning, a further useful avenue for future research might aim to enhance our understanding of the factors contributing to this deterioration, for example whether it is attributable to differences in their recognition of and response to errors. If so, in order to avoid reliance on implicit processes, which it might be might hypothesised that this group could still benefit from explicit teaching instructions if additional care was taken to avoid errors.

This study selected an experimental task to enhance control but at the expense of ecological validity. Participants' learning was therefore hyper specific and thus unlikely to generalise across settings. One aim of future studies might therefore be to replicate the findings of this study with more ecologically valid targets. This would facilitate an examination of the extent to which the learning of such targets generalises across behaviours and settings.

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PUBLIC DOMAIN BRIEFING PAPER

FACTORS AFFECTING THE USE OF TEACHING STRATEGIES IN THE REHABILITATION OF MEMORY IMPAIRMENT

PAUL VENN

Background

A number of different principles and teaching strategies are used in the rehabilitation of memory impairment. Increasingly it is acknowledged that a range of different factors may influence the effectiveness of these strategies.

Literature Review

Previous research has begun to recognise the potential impact of existing cognitive impairments when considering people for memory rehabilitation interventions. A literature review was carried out to examine the extent to which impairments of executive functioning and severity of existing memory impairment are likely to impact on intervention outcome. This literature is in its infancy, however there is some evidence that has begun to address these issues. This review concluded that at this stage, the suggestion that significant executive functioning impairments may impact negatively on memory intervention outcomes has yet to be tested in methodologically robust studies. In relation to severity of existing memory impairment, it is clear that those with more severe impairments learn less well, however little is known about the differential effectiveness of these strategies. There is a need for empirical studies with consistent measurement and definition which focus directly on these issues, in particular the impact of existing cognitive impairments on responsiveness to these different teaching strategies.

Empirical Study

Explicit memory requires deliberate recall and is often impaired following acquired brain injury, whereas implicit memory operates without deliberate recall and is generally intact in the presence of brain injury. Using word learning, this study aimed to compare teaching instructions that encouraged the use of these respective memory systems. Participants also underwent a brief neuropsychological assessment. The main aim of the study was to identify the extent to which severity of participants' existing memory impairments impacted on the benefit derived from the different teaching instructions used.

Participants

A total of 34 participants completed the study. They were recruited from two branches of Headway, a national organisation which provides support and services to people affected by brain injury.

Methodology

A cueing strategy was used to assist participants to learn two lists of words, one under each set of teaching instructions. Recall was assessed on measures of free and cued recall, immediately after the learning trials and after a week long delay. Participants' performance under each set of instructions was subsequently evaluated taking into account the difficulty of the words learned, the severity of participants' existing memory impairments and their level of executive functioning.

Results and Conclusion

The study found that the participants with less severe impairments benefitted more from the use of instructions which encouraged the use of explicit memory than those with more severe impairments. The ease/difficulty of learning each individual also impacted on this process. It was also found that the only circumstances where implicit instructions may be prefereable is where people have more severe memory impairments and lower levels of executive functioning. The findings therefore suggest that as well as existing memory impairment, level of executive functioning should be taken into account when considering people for this type of memory rehabilitation intervention.

APPENDIX 1

Author guidelines for submission to Neuropsychological Rehabilitation

APPENDIX 2

Participant Information Sheet

Title of Project: A comparison of the effectiveness of implicit and explicit instructions in teaching people with acquired memory impairment

Researchers:

I am Paul Venn. I am in the course of my professional training to become a clinical psychologist, and I am carrying out this study for the research component of my qualification. The project supervisor is Dr Gerry Riley.

- What is the purpose of this research?

  The purpose is to try to find out more about the best way to teach people with memory problems caused by brain injury during their rehabilitation.

- Why have I been invited to take part?

  Because you or your carer has reported to your Headway Centre Manager that you experience memory problems following your brain injury.

- What will happen to me if I agree to take part?

  If possible, you will be asked to participate in the study on the same day you usually attend Headway. You will be asked to participate on three separate occasions. The first two occasions will involve learning a list of words. You will then be asked some questions about the list. On the third occasion you will be asked to provide some simple information about yourself (e.g. age, date of injury etc.) and to undertake some brief assessments including a short memory assessment, a reading exercise and a short problem solving task. Each meeting will last no more than half an hour.

- Are there any risks associated with participating in the study?

  There are no risks known to be associated with taking part.

- Will I benefit in any way from participating in the study?

  Whilst it is hoped that you will enjoy participating in the study, it is not expected that there will be any direct benefit to you. However, participants may be motivated by the fact that they will be contributing to the development of scientific knowledge. It is hoped that the results of the study will have longer term benefit in being used to guide clinicians involved in memory rehabilitation work following brain injury.

- Will my participation be confidential?

Yes. You will be allocated an identification number at the beginning of the study. There will be no reference to you by name when the study is written up. Reference to your name will be in a database held by the research team, which will list your name alongside your identification number. This information will be stored on university computers only and will be password protected. It is necessary to keep such a record in case you wish to withdraw from the study. Prior to participating in the study you will be asked to sign a consent form. This will contain your identification number, and when signed this will be the only paper document which directly links your name to your identification code. Consent forms will be stored in a locked cabinet at the University of Birmingham when not in use.

No reference to any identifying characteristics of participants will be made in the publication of the study's findings. Confidential electronic files will be kept for ten years from release/publication of the findings. Paper records will be destroyed one year after completion of the research.

- What will happen if I do not want to carry on with the study?

You are free to withdraw from the study at any time. You may request that your data be withdrawn even after you have completed your participation and at any time prior to publication of the study's findings. You do not have to provide a reason if you wish to withdraw.

- What will happen to the results of the research study?

It is hoped that the study will be published in a scientific journal. It is hoped that a brief presentation summarising the findings will be presented at your Headway branch to which all those who participate will be invited. A written summary of the results provided to Headway for distribution amongst those who participated in the study.

- What happens if I have any further concerns?

Please feel free to raise any concerns with the Centre Manager at your branch or with any Headway staff. You may also wish to discuss your decision about participation with a family member or carer.

Alternatively, if you would like to discuss any aspect of this research please contact:

Paul Venn, pfv815@bham.ac.uk or Gerry Riley (Project Supervisor) – 0121 414 4923, g.a.riley@bham.ac.uk. School of Psychology, Birmingham University, Edgbaston, Birmingham, B15 2TT

APPENDIX 3

Participant Consent Form

Title of Study: A comparison of the effectiveness of implicit and explicit instructions in teaching people with acquired memory impairment.

Participant Identification Number:..

Please initial box

1. I confirm that I have understood the information sheet dated 15/01/.2010 (version 2) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my own or my loved one's medical/social care or legal rights being affected. This includes being free to request the withdrawal of my data at any stage prior to publication of the study's findings. ☐

3. I understand that the data collected during this study will be looked at by the researcher and relevant others at the University of Birmingham to ensure that the analysis is a fair and reasonable representation of the data. ☐

4. I agree to take part in the above study. ☐

....	....	....
Name of participant	Date	Signature
....	....	....
Name of researcher	Date	Signature

APPENDIX 4

Ethical Approval

APPENDIX 5

Study Words/Lists

WORD LIST A					WORD LIST B			
EASE	WORD	WORD FREQUENCY	SET SIZE		EASE	WORD	WORD FREQUENCY	SET SIZE
E	STAND	AA	9		E	BLACK	AA	8
E	WRITE	AA	3		E	HEAVY	AA	5
E	PLATE	A	7		E	ROUTE	A	5
E	VALUE	AA	5		E	GUIDE	AA	5
E	MONEY	AA	3		E	DREAM	AA	4
			MEAN SS 5.4					MEAN SS 5.4
D	EMBER	5	3		D	LABEL	7	3
D	FLICK	4	4		D	INLET	5	3
D	KNACK	4	2		D	TALLY	2	4
D	YEAST	7	2		D	CAMEL	4	2
D	ALIEN	13	5		D	QUACK	7	5
		27	16				25	17
		MEAN WF 6.6	MEAN SS 3.2				MEAN WF 5	MEAN SS 3.4

E = Easy (as defined by Jacoby (1998)); D = Difficult (as defined by Jacoby (1998)); Word frequency is per million; A and AA are high frequency ratings with a median of 47.5 per million. Set size = the number of five-letter word completions for the stems that were given by participants in the Jacoby (1998) study.

Word Order (List A): plate, yeast, ember, stand, write, knack, money, alien, value, flick.
Word Order (List B): guide, label, tally, black, heavy, inlet, dream, route, quack, camel.

APPENDIX 6

Implicit Learning Protocol (First Contact)

PROTOCOL – IMPLICIT FIRST

INTRODUCTION

- Thanks for agreeing to take part in this study. This is the first of our three proposed meetings. At each meeting I will explain what will happen during the meeting. This will include checking that you are still happy to participate in the study.

- Have you received the information sheet? Are you happy to participate in the study?

    - If yes – proceed to consent form – GET SIGNED CONSENT FORM
    - If no – provide info sheet – following discussion GET SIGNED CONSENT FORM

- Please be aware that this study relates to people with memory problems. You will not be personally judged or rated according to your performance.

- Please be aware that you have the right to withdraw from the study at any time.

- Do you have any questions about the study?

- During today's meeting you will be undertaking some tasks related to some words which I am going to show you. I'll explain more about this in a minute. Do you understand? If yes proceed, if no repeat instructions

- Are you ready to make a start?

IMPLICIT CONDITION LEARNING TRIALS

TRIAL 1

1. I am going to show you some words one at a time. The aim of the task is to try to get a list of words to stick in your memory but **without** you trying to remember them.

2. Our memories for things can work in different ways, and what we're trying to work out in this piece of research is what works best for whom.
3. So the most important thing today is that you mustn't try to remember the words, you mustn't put any effort into it.
4. Although your memory for the words will be tested later, what we are interested in is whether it helps to stay relaxed and to not try hard or to use strategies to remember things. In other words, what we're interested in is whether you remember better if you try less.
5. This is an idea that people sometimes have difficulty getting to grips with, so it might be an idea if I explain a bit more about what I mean. Do you know what it's like when you see a picture of somebody's face and you can't remember their name? You try and try to remember the name but you can't ..... then later it comes to you without even trying ..... well that's the part of your memory we're trying to access.

So are you clear about what it is you're being asked to do? Can you repeat back to me what you think you're going to be doing? Do you have any questions? If clear, proceed – If still unclear explore – repeat instructions 1-4 as necessary

OK - Just read the words as I place the cards in front of you. Just look at the word. Don't use any techniques or methods to try to remember the word. Try to clear your mind and stay as relaxed as you can. **5 second presentation for each word**

10 SECONDS BETWEEN TRIAL 1 AND TRIAL 2

TRIAL 2

Say to participants "Now I'm now going to show you the same words but with some letters missing. The number of letters missing is indicated by the number of dashes after the letters. Please add the appropriate number of letters to make a complete word. As I show them to you, clear your mind and stay as relaxed as you can. And just say the first word that comes into your head when I show you the card. Don't try to remember what you saw before or what words were on the list. Don't make any effort. Just say the first thing that comes into your head. If nothing comes into your head, just tell me and we'll move on to the next word. Remember, its most important to follow my instructions not to try hard to remember the word but to see if it comes to you without trying".

Leave each word stem on table up to 10 seconds – if correct answer, say to participant "yes that word was one of the words I showed you", record tick on on chart, transfer card to box 2 and proceed to next word stem. If no answer after 10 seconds or if answer incorrect, record **x or 0,** tell participant "that word was not one that I showed you", and/or "the word I showed you was **"xxx"",** show participant correct word (on bottom of box) return the card to Box1.

10 SECONDS BETWEEN TRIAL 2 AND TRIAL 3

Check card numbers for presentation on trial 3 correspond to cards visible at top of box 1

TRIAL 3

Say to participants "Now I'm now going to show you the same words but again with some letters missing. The number of letters missing is indicated by the number of dashes after the letters. Please add the appropriate number of letters to make a complete word. As I show them to you, clear your mind and stay as relaxed as you can. And just say the first word that comes into your head when I show you the card. Don't try to remember what you saw before or what words were on the list. Don't make any effort. Just say the first thing that comes into your head. If nothing comes into your head, just tell me and we'll move on to the next word. Remember, its most important to follow my instructions not to try hard to remember the word but to see if it comes to you without trying". "

Leave each word stem on table up to 10 seconds – if correct answer, say to participant "yes that word was one of the words I showed you", record tick on chart, transfer card to box 2 and proceed to next word stem. If no answer after 10 seconds or if answer incorrect, record **x or 0,** tell participant "that word was not one that I showed you", and/or "the word I showed you was **"xxx"",** show participant correct word (on bottom of box) return the card to Box1. If incorrect/no answer to ensure reversion to previous prompt level on next trial take top card from Box 2 and transfer to Box 1.

10 SECONDS BETWEEN TRIAL 3 AND TRIAL 4

Check card numbers for presentation on trial 4 correspond to cards visible at top of box 1

TRIAL 4

Say to participants "Now I'm now going to show you the same words but again with some letters missing. The number of letters missing is indicated by the number of dashes after the letters. Please add the appropriate number of letters to make a complete word. As I show them to you, clear your mind and stay as relaxed as you can. And just say the first word that comes into your head when I show you the card. Don't try to remember what you saw before or what words were on the list. Don't make any effort. Just say the first thing that comes into your head. If nothing comes into your head, just tell me and we'll move on to the next word. Remember, its most important to follow my instructions not to try hard to remember the word but to see if it comes to you without trying".

Leave each word stem on table up to 10 seconds – if correct answer, say to participant "yes that word was one of the words I showed you", record tick on chart, transfer card to box 2 and proceed to next word stem. If no answer after 10 seconds or if answer incorrect, record **x or 0,** tell participant "that word was not one that I showed you", and/or "the word I showed you was **"xxx"",** show participant correct word (on bottom of box) return the card to Box1. If incorrect/no answer to ensure reversion to previous prompt level on next trial take top card from Box 2 and transfer to Box 1.

10 SECONDS BETWEEN TRIAL 4 AND TRIAL 5

Check card numbers for presentation on trial 5 correspond to cards visible at top of box 1

TRIAL 5

Say to participants "Now I'm now going to show you the same words but again with some letters missing. The number of letters missing is indicated by the number of dashes after the letters. Please add the appropriate number of letters to make a complete word. As I show them to you, clear your mind and stay as relaxed as you can. And just say the first word that comes into your head when I show you the card. Don't try to remember what you saw before or what words were on the list. Don't make any effort. Just say the first thing that comes into your head. If nothing comes into your head, just tell me and we'll move on to the next word. Remember, its most important to follow my instructions not to try hard to remember the word but to see if it comes to you without trying".

Leave each word stem on table up to 10 seconds – if correct answer, say to participant "yes that word was one of the words I showed you", record tick on chart, transfer card to box 2 and proceed to next word stem. If no answer after 10 seconds or if answer incorrect, record **x or 0,** tell participant "that word was not one that I showed you", and/or "the word I showed you was **"xxx"",** show participant correct word (on bottom of box) return the card to Box1. If incorrect/no answer to ensure reversion to previous prompt level on next trial take top card from Box 2 and transfer to Box 1.

10 SECONDS BETWEEN TRIAL 5 AND TRIAL 6

Check card numbers for presentation on trial 6 correspond to cards visible at top of box 1

TRIAL 6

Say to participants "Now I'm now going to show you the same words but again with some letters missing. The number of letters missing is indicated by the number of dashes after the letters. Please add the appropriate number of letters to make a complete word. As I show them to you, clear your mind and stay as relaxed as you can. And just say the first word that comes into your head when I show you the card. Don't try to remember what you saw before or what words were on the list. Don't make any effort. Just say the first thing that comes into your head. If nothing comes into your head, just tell me and we'll move on to the next word. Remember, its most important to follow my instructions not to try hard to remember the word but to see if it comes to you without trying".

Leave each word stem on table for up to 10 seconds – if correct answer, say to participant "yes that word was one of the words I showed you", record tick on chart, transfer card to box

2 and proceed to next word stem. If no answer after 10 seconds or if answer incorrect record **x or 0,** tell participant "that word was not one that I showed you", and/or "the word I showed you was **"xxx"",** show participant correct word (printed on bottom of box) return the card to Box 1. If incorrect/no answer to ensure reversion to previous prompt level on next trial take top card from Box 2 and transfer to Box 1.

<u>FILLER TASK (2 MINS)</u>

Say to participant. You can now choose between completing a spot the difference puzzle or an object recognition task.

If STD say "I am going to show you two pictures, which are identical save for 12 minor differences. Your task is to find as many of the differences as you can in the next 2 minutes.

If OR, say "here are some copies of pictures of objects taken from unusual angles". Please record on this sheet what you think the object is.

Now for the final part of today's session. Please be aware that from now I will not be giving you any feedback as we go along as I have done previously, although I will give you some feedback at the end of the session.

<u>FREE RECALL EXERCISE</u>

> Now we're going to spend some time to see if any of the ten words shown to you at the beginning of the session come back to you. Once again, don't try hard to remember the words, just stay relaxed and see if any come into your mind. Remember, its most important to follow my instructions not to try hard to remember the word but to see if it comes to you without trying. I'm going to give you 90 seconds, and remember stay as relaxed as you can.

<u>FILLER TASK (2 MINS)</u>

Say to participant. You can now choose again between completing a spot the difference puzzle or an object recognition task.

If STD say “I am going to show you two pictures, which are identical save for 12 minor differences. Your task is to find as many of the differences as you can in the next 2 minutes.

If OR, say “here are some copies of pictures of objects taken from unusual angles”. Please record on this sheet what you think the object is.

Whilst P completing task – remove 2 letter prompts from boxes for test trial

IMMEDIATE TEST TRIAL (CUED)

Say to participants “Now I’m now going to show you the same words, with three letters missing. The number of letters missing is indicated by the number of dashes after the letters. Please add the appropriate number of letters to make a complete word. As I show them to you, clear your mind and stay as relaxed as you can. Just say the first word that comes into your head when I show you the card. Don’t try to remember what you saw before or what words were on the list. Don’t make any effort. Just say the first thing that comes into your head. If nothing comes into your head, just tell me and we’ll move on to the next word. I’m going to give you 90 seconds, and remember stay as relaxed as you can. “***You will have 10 seconds for each item”.***

AFTER 10 SECONDS PROCEED TO NEXT STEM ONCE ANSWER GIVEN - IF NO ANSWER WITHIN 10 SECONDS MOVE TO NEXT STEM.

FEEDBACK ON TEST TRIAL/FREE RECALL

Say to participants: The words were .... DUAL MODALITY OF PRESENTATION – show full word as saying it.

<u>TASK RELIANCE QUESTIONNAIRE</u>

I am now going to ask you some questions about the word completion exercises you were doing earlier, so could you please think back to these exercises:

1. At the beginning of the session, when I first started showing you the words, we talked about how you should avoid trying to remember the words or using any strategies to help remember the words. Were you able to avoid this?
2. If yes, did you answer with whatever word popped into your head first?
3. If no, what strategy(s) did you use?

That concludes today's session – I'll see you again this time next week

APPENDIX 7

Explicit Learning Protocol (Second Contact)

INTRODUCTION

-
- Thanks for agreeing to take part in this study. This is the second of our three proposed meetings.
- Are you still happy to participate in the study?
- I should remind you that this study relates to people with memory problems. You will not be personally judged or rated according to your performance.
- I should remind you that you have the right to withdraw from the study at any time.
- As at our last meeting, I will now explain what will happen during today's meeting.
- Firstly, there will be a word completion exercise.
- We will later be doing some more tasks related to words.
- Do you have any questions?
- Are you ready to make a start?

During the first part of today's session, please be aware that I will not be giving you any feedback as we go along as I did in the last session, although I will give you some feedback once we have completed the first part.

FREE RECALL EXERCISE

Now we're going to spend some time to see if any of the ten words we looked at in the last session come back to you. As we discussed last time, don't try hard to remember the words, just stay relaxed and see if any come into your mind. I'm going to give you 90 seconds, and remember stay as relaxed as you can.

FILLER TASK (2 MINS)

Say to participant. You can now choose between completing a spot the difference puzzle or an object recognition task.

If STD say "I am going to show you 2 pictures, which are identical save for 12 minor differences. Your task is to find as many of the differences as you can in the next 2 minutes.

If OR say "here are some copies of pictures of objects taken from unusual angles". Please record on this sheet what you think the object is.

DELAYED TEST TRIAL (CUED)

Say to participants "I'm now going to show you some words with three letters missing, the same words I showed you the last time we met. The number of letters missing is indicated by the number of dashes after the letters. Please add the appropriate number of letters to make a complete word. As I show them to you, clear your mind and stay as relaxed as you can. Just say the first word that comes into your head when I show you the card. Don't try to remember what you saw before or what words were on the list. Don't make any effort. Just say the first thing that comes into your head. If nothing comes into your head, just tell me and we'll move on to the next word." "***You will have 10 seconds for each item.***

AFTER 10 SECONDS PROCEED TO NEXT STEM ONCE ANSWER GIVEN - IF NO ANSWER WITHIN 10 SECONDS MOVE TO NEXT STEM.

FEEDBACK ON TEST TRIAL/FREE RECALL

Say to participants: The words were .... DUAL MODALITY OF PRESENTATION – show full word as saying it.

FILLER TASK (2 MINS)

Say to participant. You can now choose between completing a spot the difference puzzle or an object recognition task.

If STD say "I am going to show you 2 pictures, which are identical save for 12 minor differences. Your task is to find as many of the differences as you can in the next 2 minutes.

If OR say "here are some copies of pictures of objects taken from unusual angles". Please record on this sheet what you think the object is.

EXPLICIT CONDITION LEARNING TRIALS

TRIAL 1

Say to participants "I am going to show you some words one at a time". Please try and remember each word. This time if you have ways of trying to remember things that work for you, please try to use these to remember the words. For example some people find it helpful to repeat the word over and over to themselves; others imagine a picture related to the word, but you should do whatever works best for you. I'll just give you a few seconds to think about how you want to learn the words .... Do you have any questions about what you're being asked? Of we'll start then . **5 second presentation for each word**

10 SECONDS BETWEEN TRIAL 1 AND TRIAL 2

TRIAL 2

Say to participants "Now I'm now going to show you the same words again but with some letters missing. Please think back to the list you learned before and try to remember what the word is. Please try as hard as you can to remember the word".

Leave each word stem on table for up to 10 seconds – if correct answer, tell the participant it is correct, record tick on chart, transfer card to box 2 and proceed to next word stem. If no answer after 10 seconds or if answer incorrect record **x or 0,** tell participant "no that's wrong, and/or the correct answer is **"xxx",** show participant correct word (printed on bottom of box) return the card to Box 1.

If they give more than one answer, asked to choose one of them

10 SECONDS BETWEEN TRIAL 2 AND TRIAL 3

Check card numbers for presentation on trial 3 correspond to cards visible at top of box 1

TRIAL 3

Say to participants "I'm now going to show you the same words, again with some letters missing. The number of letters missing is indicated by the number of dashes after the letters). Please think back to the list you learned before and try to remember what the word is. Please try as hard as you can to remember the word".

Leave each word stem on table for up to 10 seconds – if correct answer, tell the participant it is correct, record tick on chart, transfer card to box 2 and proceed to next word stem. If no answer after 10 seconds or if answer incorrect record **x or 0,** tell participant "no that's wrong, and/or the correct answer is **"xxx",** show participant correct word (printed on bottom of box) return the card to Box 1. If incorrect/no answer to ensure reversion to previous prompt level on next trial take top card from Box 2 and transfer to Box 1.

10 SECONDS BETWEEN TRIAL 3 AND TRIAL 4

Check card numbers for presentation on trial 4 correspond to cards visible at top of box 1

TRIAL 4

Say to participants "I'm now going to show you the same words, again with some letters missing. The number of letters missing is indicated by the number of dashes after the letters). Please think back to the list you learned before and try to remember what the word is. Please try as hard as you can to remember the word".

Leave each word stem on table for up to 10 seconds – if correct answer, tell the participant it is correct, record tick on chart, transfer card to box 2 and proceed to next word stem. If no answer after 10 seconds or if answer incorrect record **x or 0,** tell participant "no that's wrong, and/or the correct answer is **"xxx",** show participant correct word (printed on bottom of box) return the card to Box 1. If incorrect/no answer to ensure reversion to previous prompt level on next trial take top card from Box 2 and transfer to Box 1.

10 SECONDS BETWEEN TRIAL 4 AND TRIAL 5

Check card numbers for presentation on trial 5 correspond to cards visible at top of box 1

TRIAL 5

Say to participants "I'm now going to show you the same words, again with some letters missing. The number of letters missing is indicated by the number of dashes after the letters). Please think back to the list you learned before and try to remember what the word is. Please try as hard as you can to remember the word".

Leave each word stem on table for up to 10 seconds – if correct answer, tell the participant it is correct, record tick on chart, transfer card to box 2 and proceed to next word stem. If no answer after 10 seconds or if answer incorrect record **x or 0,** tell participant "no that's wrong, and/or the correct answer is **"xxx",** show participant correct word (printed on bottom of box) return the card to Box 1. If incorrect/no answer to ensure reversion to previous prompt level on next trial take top card from Box 2 and transfer to Box 1.

10 SECONDS BETWEEN TRIAL 5 AND TRIAL 6

Check card numbers for presentation on trial 6 correspond to cards visible at top of box 1.

For any words which participant has correctly answered to one letter prompt, remove one letter prompts from Box 2 and place in Box 1.

TRIAL 6

Say to participants "I'm now going to show you the same words, again with some letters missing. The number of letters missing is indicated by the number of dashes after the letters). Please think back to the list you learned before and try to remember what the word is. Please try as hard as you can to remember the word".

Leave each word stem on table for up to 10 seconds – if correct answer, tell the participant it is correct, record tick on chart, transfer card to box 2 and proceed to next word stem. If no answer after 10 seconds or if answer incorrect record **x or 0,** tell participant "no that's wrong, and/or the correct answer is **"xxx",** show participant correct word (printed on bottom of box) return the card to Box 1. If incorrect/no answer to ensure reversion to previous prompt level on next trial take top card from Box 2 and transfer to Box 1.

10 SECONDS BETWEEN TRIAL 6 AND TRIAL 7

Check card numbers for presentation on trial 7 correspond to cards visible at top of box 1.

Say to participants "that concludes that task"

FILLER TASK (2 MINS)

Say to participant. You can now choose again between completing a spot the difference puzzle or an object recognition task.

If STD say "I am going to show you 2 pictures, which are identical save for 12 minor differences. Your task is to find as many of the differences as you can in the next 2 minutes.

If OR say "here are some copies of pictures of objects taken from unusual angles". Please record on this sheet what you think the object is.

Now for the final part of today's session. Please be aware that from now I will not be giving you any feedback as we go along as I have done previously, although I will give you some feedback at the end of the session.

FREE RECALL EXERCISE

> Please try and remember as many of the words from the words learned earlier as you can. There were ten words on the list. You will have 90 seconds starting from now.

FILLER TASK (2 MINS)

Say to participant. You can now choose again between completing a spot the difference puzzle or an object recognition task.

If STD say "I am going to show you 2 pictures, which are identical save for 12 minor differences. Your task is to find as many of the differences as you can in the next 2 minutes.

If OR say "here are some copies of pictures of objects taken from unusual angles". Please record on this sheet what you think the object is.

Whilst P completing task – remove 2 letter prompts from boxes for test trial

IMMEDIATE TEST TRIAL (CUED)

Say to participants "I'm now going to show you the same words, with three letters missing. The number of letters missing is indicated by the number of dashes after the letters). Please think back to the list you learned before and try to remember what the word is. Please try as hard as you can to remember the word". "***You will have 10 seconds for each item***

AFTER 10 SECONDS PROCEED TO NEXT STEM ONCE ANSWER GIVEN - IF NO ANSWER WITHIN 10 SECONDS MOVE TO NEXT STEM.

FEEDBACK ON TEST TRIAL/FREE RECALL

Say to participants: The words were .... DUAL MODALITY OF PRESENTATION – show full word as saying it.

TASK RELIANCE QUESTIONNAIRE

I am now going to ask you some questions about the word recall exercises you were doing earlier, so could you please think back to these exercises:

1. At the beginning of the session, when I first started showing you the words, I suggested you should use some way of trying to learn the words. Did you use anything?
2. If yes, what did you use?
3. If no, did you answer with whatever word popped into your head first?

That concludes today's session – I'll see you again next week

APPENDIX 8

Mean Scores by Word List and Teaching Order

<u>Mean Scores for Each Teaching Strategy by Order</u>

	Mean score under implicit conditions	Mean score under explicit conditions
Order 1 (A/B)	6.56	10.89
Order 2 (B/A)	9.67	13.78
Order 3 (A/B)	8.13	9.25
Order 4 (B/A)	10.00	9.63

Order 1: List A (explicit instructions) followed by List B (implicit instructions)

Order 2: List B (explicit instructions) followed by List A (implicit instructions)

Order 3: List A (implicit instructions) followed by List B (explicit instructions)

Order 4: List B (implicit instructions) followed by List A (explicit instructions)

<u>Mean Scores for Each List by Order</u>

	Mean score List A	Mean score List B
Order 1	10.89	6.56
Order 2	9.67	13.78
Order 3	8.13	9.25
Order 4	9.63	10.00

Mean Participant Scores by Order of Teaching Strategy

	Mean score under Implicit conditions	Mean score under explicit conditions
Learned first under explicit conditions	16.22	24.67
Learned first under implicit conditions	18.13	18.88

Mean Participant Scores by List Order

	Mean score under Implicit conditions	Mean score under explicit conditions
List A, List B	14.69	20.14
List B, List A	19.67	23.41

APPENDIX 9

Immediate Free Recall Data by Executive Functioning Group

Effects (Low Executive Functioning Group)

Within Subject Effects	F	sig
Implicit(1)/Explicit(2)	3.965	.072
Easy(1)/Hard(2)	1.573	.236
Implicit/Explicit x Memory Group	1.140	.309
Implicit/Explicit x Memory Group x Easy/Hard	4.618	.055
Between Subject Effects	F	sig
Memory Group	26.721	.000

Effects (High Executive Functioning Group)

Within Subject Effects	F	sig
Implicit(1)/Explicit(2)	7.884	.020
Easy(1)/Hard(2)	.095	.765
Implicit/Explicit x Memory Group	.031	.864
Implicit/Explicit x Memory Group x Easy/Hard	.420	.533
Between Subject Effects	F	sig
Memory Group	6.631	.030

Effects (Low Executive Function Group, Easy Words)

Within Subject Effects	F	sig
Implicit(1)/Explicit(2)	6.007	.032
Implicit/Explicit x Memory Group	6.874	.024

Effects (Low Executive Function Group, Hard Words)

Within Subject Effects	F	sig
Implicit(1)/Explicit(2)	.945	.352
Implicit/Explicit x Memory Group	.175	.683

Effects (High Executive Function Group, Easy Words)

Within Subject Effects	F	sig
Implicit(1)/Explicit(2)	2.469	.151
Implicit/Explicit x Memory Group	.208	.659

Effects (High Executive Function Group, Hard Words)

Within Subject Effects	F	sig
Implicit(1)/Explicit(2)	11.238	.008
Implicit/Explicit x Memory Group	.048	.831

APPENDIX 10

Delayed Cued Recall Data by Item Difficulty

Delayed Cued Recall: Effects (Easy Words)

Within Subject Effects	F	sig
Implicit(1)/Explicit(2)	3.209	.085
Implicit/Explicit x Memory Group	3.743	.064

Delayed Cued Recall: Effects (Hard Words)

Within Subject Effects	F	sig
Implicit(1)/Explicit(2)	2.248	.146
Implicit/Explicit x Memory Group	3.678	.066