UNIVERSITY OF SOUTHAMPTON

VERY LONG-TERM MEMORY IN PEOPLE WITH TEMPORAL LOBE EPILEPSY

BY

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A thesis submitted in partial fulfilment of the requirements for the degree of D.Clin.Psychol.

Faculty of Social Sciences
Department of Psychology
July 2002
17, 153 words

Contents

Acknowledgements

My thanks have to go, first and foremost, to my supervisors, Narinder Kapur and Romola Bucks, for their patience, encouragement and support. I would also like to thank the participants who expressed an interest in my research and gave up their time to participate. Finally, I have to thank my partner, Gavin, for tolerating my distraction over the past few months, for his endless support and never doubting that I would finally finish.

Thesis Abstract

Memory has been extensively studied in epilepsy. There are numerous accounts of memory impairments being found, particularly for people with temporal lobe epilepsy. Many discrepancies are, however, also evident. The first paper outlines the literature on memory problems in epilepsy. It focuses on the impairments reported in people with temporal lobe epilepsy in neuropsychological studies and cognitive neuroscience research and reviews the evidence concerning the presence and type of memory difficulties. Attention is then turned to the role of other factors in contributing to these difficulties, including epilepsy-related variables and psychological factors. The main conclusion drawn is that studies have not adequately acknowledged the possible role of these other factors when exploring memory impairments which presents a major methodological problem and more constrained studies are required to allow an understanding of the deficits experienced.

The second paper describes a study which investigated the presence of remote memory loss in people with temporal lobe epilepsy. A mild remote memory impairment was found for people with left temporal lobe epilepsy for both episodic autobiographical memory and semantic memory for public events. Support was given to the view that more sensitive tests of remote memory are required which allow the detection of subtle differences in performance. The need for future research with improved methodologies is discussed along with the potential clinical implications of such research.

Literature Review Paper

Memory Change in Epilepsy: A Review of the Evidence

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This paper has been prepared for submission to Brain (see Appendix I for instructions for authors).

Running head: Memory Change in Epilepsy

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Summary

Epilepsy is a common neurological condition which is associated with a range of cognitive, behavioural and emotional difficulties. A complex interaction of epilepsy-related and psychosocial variables is considered to contribute to the level of difficulty experienced. Memory impairments are the most frequently reported cognitive difficulty and are associated with quality of life ratings. This paper reviews the literature on memory in epilepsy conducted in neuropsychological studies and research in cognitive neuroscience, much of which has focused on memory in people with temporal lobe epilepsy. There have been many reports of lateralised material specific deficits, with verbal memory impairments in people with left temporal lobe epilepsy and non-verbal memory deficits in people with right temporal lobe epilepsy. Impairments on tests of remote memory have also been identified. There are, however, considerable discrepancies within the literature with little consistency in the memory impairments found. A number of methodological issues are present within these studies. Limitations are associated with the multi-factorial nature of the memory impairments, including variables related to the epilepsy which lead to heterogeneous groups, and the poor sensitivity of the neuropsychological tests used. Future research is required which will address the methodological limitations in order to understand the full implications and potential clinical applications of the findings.

Introduction

The clinical picture of epilepsy

Epilepsy is defined as a condition in which the person experiences recurrent epileptic seizures (Shorvon, 2000). Seizures arise from over-activity of a group of neurons at the site of structural pathology or abnormal brain tissue (Oxbury, 1997) and result in altered behaviour with or without change in the person's level of consciousness (Cull and Goldstein, 1997). The epileptic activity may remain localised in the original site, which is termed a focal seizure, or may spread throughout the cortex, described as a generalised seizure. Three main types of epileptic seizures are outlined, these are; partial (simple and complex) seizures in which consciousness is unaffected or altered respectively; generalised secondary seizures in which consciousness is affected; and unclassified epileptic seizures. These types of epilepsy are further subdivided into different forms within these three main groups (Commission on Classification and Terminology of the International League Against Epilepsy, 1981). The effect the epileptic activity will have is dependent on a variety of factors, including the location of the focus of the activity, the pattern of spread in the brain, whether it interferes with consciousness, the duration of the seizure, and which brain mechanisms are interrupted.

Epilepsy is a common neurological condition with a reported incidence of between 50 to 120 cases per 100 000 people per year (Shorvon, 2000). The cumulative incidence of developing epilepsy during an individual's life span is between 3 to 5%. It has been estimated that there are approximately 350,000 people with a diagnosis of epilepsy in the UK (Brown and Betts, 1994). The

highest incidence rates are observed in neonates and young children, with a second peak in old age (Shorvon, 2000).

Epilepsy is considered to be a symptom rather than a disease (Lishman, 1987), with a large number of diverse aetiologies which have been associated with the onset. Where a cause can be identified it has been associated with a variety of aetiologies including inherited genetic disorders and acquired or congenital disorders such as: brain damage; acute and chronic infections; and cerebrovascular disease. In a large proportion of cases, the aetiology may remain unknown (Lishman, 1987).

Problems associated with epilepsy

Given the number of different possible aetiologies and factors which influence the effect of epilepsy there is considerable variability in the severity and clinical features of difficulties which can be associated with it (Shorvon, 2000). On a psychological level, behavioural and emotional difficulties have been reported. These difficulties have been proposed to be the interaction of brain damage which has led to the onset of the epilepsy, the effects of anti-epileptic medications to control the seizures and the psychosocial effects of living with a stigmatising disorder (Baker, 1997). This last difficulty may influence many areas of a person's life, for example, by placing restrictions on vocational or leisure interests, either as a result of the epilepsy or through other people being overprotective and denying the person the opportunity for typical everyday activities (Betts, 1998). Epilepsy, therefore, can be considered to have significant social effects. Indeed, in a recent survey of more than 5,000 people with epilepsy living in 15 European countries 51% reported feeling stigmatised (Baker *et al.*, 2000).

Cognitive difficulties have also been frequently reported. These impairments have been noted to arise in a range of areas of cognitive functioning, including general intelligence, language, executive function, and memory (Oxbury, 2000). These difficulties too can have far reaching psychosocial implications. A link has been found between level of cognitive functioning and quality of life (Trimble, 1994), with cognitive function shown in many chronic conditions, including epilepsy, to be related to vocational and educational achievements. The effect of impairments in cognitive functioning, however, is not straightforward and, as Trimble (1994) notes, this will be mediated by an individual's life situation and the demands placed upon their cognitive abilities. In addition, cognitive impairments are considered to be multi-factorial in origin (Betts, 1998), with a large number of factors proposed to exert an influence. These include variables relating to the epilepsy, such as age of onset, type, and duration; anti-epileptic medication; and the nature and location of the underlying pathology (Oxbury, 2000). Additional effects on cognitive functioning have also been considered to occur through a direct effect of epilepsy on mood (Quiske *et al.*, 2000) and motivation which may in turn contribute to learning and cognitive impairments (Betts, 1998).

The most predominant cognitive complaint made by people with epilepsy is memory difficulties (Corcoran and Thompson 1992a; Loiseau *et al.*, 1988). In a survey completed by a large group of people with epilepsy 54% rated their memory as a moderate or severe nuisance. In contrast, only 23% of a control group rated their memory in this way (Corcoran and Thompson, 1992a). The three most frequent memory problems reported in this survey were 'finding a word is on the tip of the

tongue', 'having to go back and check you have done something' and 'forgetting when you were told something yesterday or a few days ago'.

Focus of this review

The identification of memory difficulties in people with epilepsy has important clinical implications in terms of issues relating to quality of life and managing everyday memory difficulties. This review will, therefore, focus on the memory impairments experienced. Many of these studies have developed from a cognitive neuroscience perspective and have attempted to understand the form of deficits and how this can inform models of memory. A more clinical perspective is also evident, in which studies have employed neuropsychological assessments of memory in epilepsy to inform investigations of lateralisation of cerebral dysfunction prior to surgery for intractable epilepsy. The primary aim of this paper is to review the neuropsychological studies reported from these perspectives, to highlight their findings and to discuss their implications for our understanding of memory impairments in epilepsy.

Before beginning to outline the literature, the extensive nature of the studies in epilepsy means that it is important to clarify the area which this review will cover. Firstly, studies which have explored memory functioning in epilepsy can be separated into those which have examined the presence of transient memory impairments experienced during a seizure and those which have explored the more permanent memory difficulties which people experience between seizures. The focus, here, will concentrate on this latter form of memory deficits as this form of

impairment of functioning is considered to be clinically more meaningful and reflects the experience of the everyday memory difficulties for the individual.

Secondly, because of the considered importance of temporal lobe structures to memory, a significant proportion of memory in epilepsy literature relates to studies involving people with temporal lobe epilepsy (TLE) (Goldstein, 1997). People with TLE have a unilateral epileptic focus as a result of damage to the temporal lobes, often arising from lesions to the hippocampus. Within these studies, many also include people who have undergone some form of unilateral temporal lobe resection, most typically a temporal lobectomy, to control intractable epilepsy. The review will reflect this focus within the literature although, where possible, studies involving people with other types of epilepsy will be described.

Memory and epilepsy

Studies of the association between memory and epilepsy have increasingly become a focus for cognitive neuroscience research in epilepsy over the past 40 years. From this perspective researching memory impairments in people with epilepsy has been suggested to be very important for memory research, as "focal epileptic disorders often affect cerebral subsystems that are very important for (at least declarative) memory, namely the frontotemporal limbic system & the temporal prefontal neocortex" (Helmstaedter and Kurthen, 2001) (sic). As Synder (1997) notes, people with TLE are seen to provide a "natural laboratory" for the study of human memory, for both investigating the distribution and functional organisation of the cerebral subsystems of memory and testing cognitive and anatomical models.

Studies of verbal and non-verbal memory

Studies which have investigated the learning and later retrieval of new information in people with TLE comprise a large part of the literature. Numerous studies have shown that people with TLE have a memory impairment when compared to controls or people with other focal epilepsy (Oxbury, 2000). The most consistent findings reported are of verbal memory deficits on story recall and word list learning tasks in people with left TLE (Delaney *et al.*, 1980; Giovagnoli *et al.*, 1996; Giovagnoli and Avanzini, 1999; Hermann *et al.*, 1987; Hermann *et al.*, 1997), and specifically left TLE as a result of hippocampal sclerosis (Baxendale *et al.*, 1998a; Saling *et al.*, 1993). There have also been reports of non-verbal memory problems on figure memory tests in people with right TLE (Delaney *et al.*, 1980; Helmstaedter *et al.*, 1991), and specifically for right TLE due to hippocampal sclerosis (Baxendale *et al.*, 1998a). This material-specific deficit has also been demonstrated for recognition memory using the words and faces of the Recognition Memory Test (Warrington, 1984) in people who have undergone a temporal lobectomy (Morris *et al.*, 1995). However, there are inconsistencies in the reports and studies have reported failure to find selective deficits, both for a non-verbal material-specific effect for people with right TLE (Giovagnoli and Avanzini, 1999; Hermann *et al.*, 1987), and a verbal deficit in people with left TLE (Goldstein, 1997). Possible explanations for the discrepancies within these reports are differences in the test protocols (Goldstein, 1997; Loiseau *et al.*, 1988), task demands (Saling *et al.*, 1993), and heterogeneity in the groups (Baxendale *et al.*, 1998a). In contrast with the above studies other reports have observed that people with TLE referred to neuropsychological services for an evaluation of memory

difficulties perform at average or higher than average levels (Thompson and Corcoran, 1992). These conflicting findings may, again, be due to differences in the participant groups included, possibly due to the services through which people are recruited.

Memory in TLE has also been investigated over a longer time period than that assessed by conventional memory tests. Blake *et al.* (2000) used a prospective study of very long-term verbal memory to test recall after a retention interval of 8 weeks. Despite people with TLE showing normal learning and retention on the task over a 30 minute interval when first assessed, the performance of participants with left TLE was below that of participants with right TLE and controls when tested several weeks later. Similar findings have also been reported for a difference in performance across a shorter time interval. Whilst no difference was found between a group of participants with epilepsy (comprising participants with TLE and people who had undergone a temporal lobectomy) and controls, for recall of a word list after a 30 minute delay, participants with TLE showed a disproportionate impairment when tested following a delay of 24 hours (Martin *et al.*, 1991). No difference in performance was found between people with left or right temporal lobe epileptic focus.

Single case studies provide detailed accounts of the memory difficulties experienced by people with epilepsy. Kapur *et al.* (1997) described a woman with TLE who presented with complaints of memory problems for events which had occurred over the previous 3-24 months. Her difficulties had significant psychosocial implications as she found herself inhibited in her social

conversation due to difficulties recalling past information about friends. Her difficulties were reflected in her test performance. On standard memory and cognitive tasks her performance was found to be excellent and on a prospective memory test was found to be similar to controls following a 30 minute delay. However, after a 6 week delay she showed a significant impairment and indeed reported no recollection of the testing having taken place.

The above studies provide evidence to suggest that ongoing seizure activity may contribute to memory impairment by disrupting processes involved in the consolidation of newly acquired information (Bergin *et al.*, 2000). This argument was supported in a recent study by Jokeit *et al.* (2001) in which people with TLE were assessed on a word-position learning task during video EEG monitoring. The study found impaired performance in people with left TLE if they had experienced a seizure in the preceding 24 hours. From this finding it was concluded that seizures can impair the consolidation of memories beyond the memory deficits caused by the underlying pathology.

Remote memory

Tests of remote memory concern the ability to recall past information and typically either examine performance on autobiographical memory tests or tests of public knowledge and famous people. People with epilepsy have reported that they cannot remember events from the past and often find the loss of their memories distressing (Upton *et al.*, 1992). A clear example of the psychosocial implications of this form of memory difficulty was indicated in the single case example above described by Kapur *et al.* (1997).

However, there has been relatively little research into the effects of epilepsy on remote memory (Bergin *et al.*, 2000). This may be due, in part, to the fact that standard neuropsychological assessments of memory carried out in Epilepsy Services are unlikely routinely to assess memory for past events. Research in this area is also methodologically more difficult as it is not possible to control for, and easily measure, task variables that may influence memory performance (Butters and Cermak, 1986; Gloor, 1997). The research in people with TLE which has been carried out in this area has shown variability in the findings.

Viskontas *et al.* (2000) tested 25 individuals with unilateral TLE with a range of aetiologies, who were either being assessed for, or had already undergone, surgery. They found that the participants with epilepsy performed significantly worse than controls on the autobiographical incidents component of the Autobiographical Memory Interview (Kopelman *et al.*, 1990), whilst there was no difference on the personal semantic items. Within the epilepsy group no significant differences in the autobiographical incidents task were found to be associated with the epilepsy variables, including age of onset, preoperative versus postoperative status, and affected hemisphere performance. The findings also demonstrated a lack of a temporal gradient to the autobiographical memory deficit, with the impairment extending into early childhood. Similarly Barnett *et al.* (2000) found retrieval of autobiographical memory in people with chronic epilepsy to be impaired on an autobiographical fluency task. However, in this study epilepsy variables were not assessed and the epilepsy group used was somewhat heterogeneous. In a more homogenous group of people with TLE some effect of the hemisphere of epileptogenic focus on autobiographical memory performance was reported by Blake

(1999). Scores for people with a left temporal lobe focus for their epilepsy were found to be below those with a right temporal focus on the early part of the autobiographical incidents section of the Autobiographical Memory Interview (Kopelman *et al.*, 1990) but the difference did not reach statistical significance.

Remote memory performance on tests of both autobiographical memory and memory for public events was assessed by Barr *et al.* (1990). Two groups of people who had undergone a left or right unilateral temporal lobectomy were tested, along with a matched control group without epilepsy. The tests included recognition of famous faces and recognition of past television programmes as well as public event knowledge and autobiographical knowledge. The group who had undergone a left temporal lobectomy was found to perform consistently worse than both the group who had undergone a right temporal lobectomy or controls on these tests. However, a ceiling effect was noted to for these latter two groups. A similar remote memory impairment was reported by O'Connor *et al.* (1999). Again, the left temporal lobectomy group were found to perform worse than the right temporal lobectomy group on a factual public events test, although in this study performance on an autobiographical memory test was found to be equal across the groups.

In people with TLE memory for public events, for both recall and recognition was found to be impaired when compared to controls (Ratti *et al.*, 1992). Unlike the previous studies no significant difference was found between participants with left and right hemisphere seizure focus. Interestingly, this study compared events from both before and after the onset of the epilepsy. The remote memory loss was found to be more marked for the years after onset, supporting accounts of memory

consolidation difficulties in epilepsy. In a recent study, people with TLE were found to be significantly impaired when compared with people with extratemporal epilepsy and primary generalised epilepsy as well as controls on a test of public event memory (Bergin *et al.*, 2000). The performance of the people with other types of epilepsy was similar to that of the controls, suggesting that the impairment observed in the TLE group was not related simply to the presence of epilepsy. As with the previous study, there was no significant difference between the performance of people whose seizures arose from the left or right hemisphere. The absence of a selective deficit in this study was attributed to the potential verbal and visual components of memory for public events (Bergin *et al.*, 2000). Within remote memory, the ability to recognise and identify famous faces across four time periods was found to significantly differ between people with left or right TLE (Seidenberg *et al.*, 2002). While the left TLE group was able to recognise and give semantic information about the famous faces but showed a selective impairment for naming, the right TLE group showed an impairment for all three areas. The difference across the findings reported here would seem to suggest that the form of deficit found within these studies is strongly related to the specific method of assessment used.

Summary of research findings

In summary, studies of memory functioning in epilepsy have reported a higher prevalence of neuropsychological dysfunction in people with epilepsy than is found in the general population (Kwan and Brodie, 2001). There is a great deal of inconsistency within these accounts, however, with reports of performance within normal limits on standard neuropsychological tests also being observed (Thompson and Corcoran, 1992). Within the studies which have reported the presence of

memory impairments there is considerable evidence of a lateralised material-specific deficit in people with TLE but again inconsistencies have been demonstrated which may relate to the groups included and tasks administered. In addition, studies have shown that epilepsy may affect the long-term consolidation of memories leading to normal levels of performance over short intervals but a memory deficit for the information when tested later. Finally, impairments in remote memory have also been demonstrated, both for autobiographical memory, and memory for public events, although the picture in terms of hemisphere lateralisation is unclear.

Limitations of the research literature

Many of the studies which report evidence of memory impairments in epilepsy make comment about the range of factors which may be associated with memory performance. These factors include the underlying pathologies, neuronal discharges, anti-epileptic medication, and psychosocial issues (e.g. Baxendale *et al.*, 1998a; Corcoran and Thompson, 1993). The multifactorial nature of the memory impairments highlights the methodological difficulty of controlling for all the possible influencing variables related to the epilepsy which may influence memory performance. The inability to control for these variables within the studies limits the meaningful interpretation of the results. Thus, while an association can be noted between epilepsy and memory, any explanation in terms of causation can not necessarily be implied. These other variables, therefore, could also be considered to represent factors which may have produced test results similar to those reported in the above studies. Other common methodological problems within these studies relate to the participant groups used and the limitations of the neuropsychological tests (Dodrill, 1992). This next section will consider these confounding variables in

more detail and will make comment on studies which have demonstrated the effect these may have on memory performance.

Anti-epileptic medication

There is a growing interest in the impact of anti-epileptic medication on people with epilepsy, in particular, in the extent to which it exerts an effect on cognitive and behavioural functioning (Gillham and Cull, 1997). Conflicting accounts are reported within the literature. Some studies report that anti-epileptic treatments consistently produce adverse, albeit subtle, cognitive consequences (Gillham *et al.*, 1990). Other studies, however, have reported that when cognitive deterioration is explored longitudinally no mental losses are shown over 5 years in individuals on established drugs with concentrations within the target ranges and in the absence of an active seizure disorder (Dodrill and Wilensky, 1992).

The adverse effects of anti-epileptic medication have been found to be particularly prominent in people receiving polytherapy (Kwan and Brodie, 2001), higher dosages, and higher anti-epileptic drug blood levels (Loring and Meador, 2001). Indeed, studies have shown that a reduction in the number of anti-epileptic drugs, or a change to monotherapy, can result in cognitive and behavioural improvement (Gillham and Cull, 1997). This improvement, however, is suggested to be mediated by the beneficial effects on seizure frequency, which is also considered to influence memory and cognition (see section below). Thus, although a lot of negative effects of anti-epileptic treatments on functioning have been reported, medication has been noted also to have a positive effect through increased seizure control (Kwan and Brodie, 2001; Loring and Meador, 2001).

New drug treatments, introduced in the last 10 years, are considered to have less cognitive side effects than the older, well established drugs (Brunbech and Sabers, 2002; Loring and Meador, 2001), with all but one showing little effect on memory (Helmstaedter and Kurthen, 2001). The effects of these new treatments, however, have yet to be systematically studied (Loring and Meador, 2001). Methodological problems with the studies carried out also reduce the significance of the findings (Brunbech and Sabers, 2002; Gillham and Cull, 1997). Investigations into the effects of medication have failed to take account of the other variables which may also affect memory and other areas of cognition, such as variables related to the epilepsy or mood (Brunbech and Sabers, 2002). Furthermore, there has been wide variation in the cognitive assessments used and this has hindered the comparison of findings between studies (Gillham and Cull, 1997). Further extensive systematic studies are called for which can improve on these methodologies (Thompson, 2001).

Circumscribed nature of the groups included in the studies

Research in epilepsy, including that on anti-epileptic medications, has only been carried out on a very restricted range of participants. Studies of cognitive functioning in epilepsy often exclude people on the basis of IQ which prevents understanding of the full picture in terms of the effects on neuropsychological functioning (Oxbury, 2000). The participant samples used in these studies have frequently recruited people through large medical centres and as a result individuals with difficult to control epilepsy may be over represented within these groups which could make a large difference to the findings (Dodrill, 1992).

With regard to anti-epileptic medications, there has been no investigation of the effects in older adults or in people with learning disabilities, despite both of these groups representing significant populations within epilepsy (Gillham and Cull, 1997). These restrictions are clinically very significant since cognitive or behavioural effects of the epilepsy, or medication, would have the greatest influence on these very groups, in whom cognitive functioning may, to some extent, already be compromised (Betts, 1998).

Epileptic focus

As was noted earlier, a large proportion of the studies of memory in epilepsy have focused on the level of functioning in people with TLE. The extensive study of this population has been due to the well known relationship between temporal lobes and memory, and the frequent reporting of studies involving the assessment of people with unilateral seizures in the temporal lobes being considered for temporal lobectomy (Oxbury, 1997). However, because of the interest in exploring the cerebral lateralisation of memory functions in people with unilateral TLE, there has been little research into the neuropsychological deficits of individuals whose seizures arise in both temporal lobes (Oxbury, 2000). This absence of research is despite the fact that bilateral temporal lobe damage is consistently associated with severe amnesia (Fujii *et al.*, 2000; Gloor, 1997).

Furthermore, interest in memory impairments in people with TLE has not been matched in other epilepsy groups, with studies failing to investigate memory difficulties in these populations. This is despite the fact that when the level of memory complaints made by people with epilepsy has been compared

between people with TLE and those with other seizure disorders, or between groups of left and right temporal lobe focus, no differences have been found (Corcoran and Thompson, 1993).

Type of seizure

Studies have also shown that seizure type can have a determining influence on cognitive performance, but the findings are inconsistent (Kwan and Brodie, 2001) and appear to depend on the type of cognitive functioning assessed. Both complex partial seizures (the type of seizure typically occurring in TLE) and secondary generalised seizures have been noted to be associated with cognitive impairments in memory (Prevey *et al.*, 1998; Pulliainen *et al.*, 2000). People with generalised seizures have often also been found to be impaired on tests of concentration and attention which can indirectly affect memory performance (Trimble, 1994).

Brain pathology

Many of the studies investigating memory in epilepsy have used heterogeneous groups which included people with a variety of pathologies (Oxbury, 2000). Even within the studies of people with TLE the aetiology, extent and nature of the underlying pathologies is varied (Baxendale *et al.*, 1998a). This clearly poses difficulties for the interpretation of the findings since any memory deficits identified may be due to the underlying brain pathology responsible for the epilepsy (Loiseau *et al.*, 1988; Sander and Hart, 1997). Furthermore, pathological processes in epilepsy have been found to alter the cerebral organisation of memory functioning (Dupont *et al.*, 2000) which may make the interpretation of results in mixed pathology groups difficult. A focus on specific

pathologies within the studies has been noted in the last ten years (Oxbury, 2000), particularly for people with unilateral hippocampal sclerosis, which represents a step towards improving this problem.

The move towards single pathology groups is also called for by research that suggests that different pathologies underlying the epileptic focus can lead to different cognitive consequences, even if at the same anatomical site (Kwan and Brodie, 2001). An example of this is hippocampal sclerosis, which has been found to be associated with a greater impairment in intelligence, academic achievement, language and visuospatial functions than other pathologies (Hermann *et al.*, 1997). Furthermore, the severity of the pathology has also been found to have an effect. The greater the degree of left hippocampal sclerosis, the more severe the extent of the verbal memory deficits (Kilpatrick *et al.*, 1997).

In contrast to these findings, however, Giovagnoli and Avanzini (1999) argued that the pathological characteristics and location of any lesion were not found to be important in determining learning and memory in groups of participants with lesional or cryptogenic TLE once clinical and treatment factors were taken into account. The conclusions from these findings were that it was the epileptic discharges, rather than the lesions, which affected memory functioning.

Frequency of seizures

People whose seizures are poorly controlled have been reported to experience greater memory impairments, with seizures having a direct effect on cognitive functioning (Giovagnoli and Avanzini, 1999). Dodrill (1986) found that a history

of status epilepticus, or more than 100 individual convulsions, was associated with decreased functioning across the areas of intelligence, neuropsychological functioning, emotional adjustment and psychosocial functioning. These findings suggest that studies need to match for seizure frequency when assessing memory in epilepsy. Seizures have also been argued to disturb cognitive functioning for a period after a seizure, sometimes for several days (Loiseau *et al.*, 1988). If seizures occur frequently Loiseau *et al.* (1988) have suggested that cognitive functioning may not have an opportunity to recover. Few studies make reference to the time period between the neuropsychological testing and the individual's last seizure, yet according to this view, this may significantly affect a person's ability to perform the tasks.

Seizures themselves have also been suggested to cause brain damage if they are prolonged or frequent (Sander and Hart, 1997). In other cases, subictal seizure activity may occur frequently and although this may be insufficient to cause clinical seizures, the discharges may interrupt the mechanisms of memory and learning (Betts, 1998; Loiseau *et al.*, 1988; Sander and Hart, 1997). Some attempts to assess the impact of this have used EEG recordings to assess the degree to which epileptic activity may be occurring (Jokeit *et al.*, 2001). Clearly, however, this is very invasive, and could only be used to assess the effect of any epileptic activity over very short durations.

Age of onset of epilepsy

The age of onset of the epilepsy can be a significant factor for memory performance as this can modify the normal functional organisation of the brain

(Loiseau *et al.*, 1988). The occurrence of seizure activity during critical periods of neural development has been considered to result in chronic cognitive difficulties (Rice and Barone, 2000). A difference in neuropsychological test performance has been found between people with early onset (0-5 years) and late onset (10 years and over) TLE (Lespinet *et al.*, 2002). People with early onset TLE showed major verbal and non-verbal deficits, whereas the late onset group showed minor specific deficits which adhered to the material-specific lateralisation, with verbal deficits in people with left TLE and non-verbal deficits in people with right TLE.

Surgery

Surgical treatment of epilepsy carried out specifically to control focal epileptic seizures has increased over the last decade. The most common resective procedure is a temporal lobectomy carried out for people with intractable partial seizures related to TLE (Betts, 1998). Surgery has been found to have serious negative side-effects on memory (Baxendale *et al.*, 1998b; Helmstaedter and Kurthen, 2001). Verbal memory deficits have been reliably found following surgery in people with left sided dominance (Frisk and Milner, 1990; Lee *et al.*, 2002) and non-verbal memory deficits have been found, but less consistently so, in people following right non-dominant operations (Jones-Gotman, 1986). The extent of the impairment following surgery has been attributed to the damage or removal of brain tissues still involved in memory functioning, the brain's ability to cope with the damage and the secondary effects of successful seizure control (Helmstaedter and Kurthen, 2001). Postoperative shrinkage of the remnant hippocampus may also affect memory (Baxendale *et al.*, 2000).

Level of self-reported memory difficulties

Studies of memory in epilepsy have found that the level of reported difficulties can appear inconsistent with functioning on neuropsychological memory tests (Thompson and Corcoran, 1992; Upton *et al.*, 1992). These observations have led to suggestions that a discrepancy exists between the frequent complaints of memory difficulties made by people with epilepsy and level of performance, which is often within normal limits on standard neuropsychological tests of memory (Vermeulen *et al.*, 1993). This discrepancy has been explained in terms of a tendency for people with epilepsy to overestimate the level of their difficulty due to neurosis (Vermeulen *et al.*, 1993), or to be unduly anxious about minor memory problems (Sander and Hart, 1997). For example, in 150 people with epilepsy no correlation was found between a memory questionnaire and performance on memory tests (Piazzini *et al.*, 2001). The tendency for the group with epilepsy to overstate memory problems was found to be highly related to levels of depression and anxiety, whereas it was not associated with the type or duration of the epilepsy. Whilst this finding highlights the significance of emotional factors in influencing people's perceptions, other possible explanations related to the insensitivity of the memory tests and questionnaires for identifying everyday memory problems should not be overlooked. In this study seizure frequency was found to be related to mood, and, as has been shown in the early section, this can also exert a direct effect on memory performance and may have influenced these findings.

Other studies have disputed the suggestion that high levels of reported memory problems are simply an exaggeration caused by low mood (Corcoran and Thompson, 1992b). This investigation of reported levels of memory problems compared

retrospective reports with prospective recordings of everyday memory failures. The results demonstrated that far from overemphasising memory problems people with epilepsy were found actually to underestimate them. The discrepancy in these findings could be related to differences in the groups of people with epilepsy tested. This study also used a very different approach to assessing the level of memory difficulties through the use of a retrospective memory questionnaire and a prospective memory checklist which was completed daily rather than standard neuropsychological tests.

Attribution of cognitive deficits

One possible explanation for the performance-complaint discrepancy is differences in what people mean when they report memory difficulties. The inspection of responses in one self-report study of memory in people with epilepsy suggested that other cognitive problems, including language and organisational difficulties, were underlying or contributing to the reported difficulties, but were being misattributed to memory by the participants (Corcoran and Thompson, 1993). In line with this, cognitive deficits in naming (Mayeux *et al.*, 1980), effortful or controlled processing (O'Shea *et al.*, 1996), or general retrieval (Hermann *et al.*, 1988), have all been suggested to underlie reported memory deficits. These discrepancies are, therefore, suggested to arise from the fact that people base their assessment of their memory performance on verbal behaviours and subjective memory theories, rather than according to a definition of memory from a neuropsychological perspective (Helmstaedter and Elger, 2000).

Mood

An association between mood and memory performance is well known. In epilepsy, as has been noted, temporal lobe damage has been proposed as a predisposing factor for mood disorders in focal epilepsy (Quiske *et al.*, 2000). A correlation between perceived cognitive functioning and mood has been noted (Elixhauser *et al.*, 1999; Piazzini *et al.*, 2001), and people with epilepsy who report memory problems have been found to be more likely to feel depressed and anxious, as well as having a later age of onset of seizures (Corcoran and Thompson, 1993). The extent to which emotional factors have been considered to increase reports of memory difficulties has varied. Giovagnoli *et al.* (1997) suggested that while the subjective perception of memory failure did reflect an objective memory impairment, the level of reported difficulty was increased by emotional factors and low self-esteem.

The validity of memory tests

The validity of the different tests and questionnaires being employed in the studies has been questioned. Memory questionnaires used to obtain self-reported levels of difficulty have been criticised because of their generally weak correlations with more traditional neuropsychological tests (Thompson, 1997). Indeed, the information provided by memory tests has been argued to be qualitatively different to that provided by self-report measures (Elixhauser *et al.*, 1999).

Clinical tests of memory used to look at the learning and recall of verbal and non-verbal material may not be equally difficult and a wide variety of different tests, both standardised and experimental, have been used. Furthermore, some of these tests may not measure what they purport to, for example non-verbal test performance can

often be mediated by the use of verbal strategies to aid recall of information (Giovagnoli and Avanzini, 1999). This has led to calls for the development of better standardised tests (Oxbury, 2000). These assessments also tend to focus on the short-term/long-term memory distinction with tasks which measure memory either after seconds or minutes. Whilst, these assessments are designed to be sensitive to memory impairments in the typical amnesic syndrome they have been argued to be unsuitable for assessing memory in epilepsy (Blake *et al.*, 2000). As Bergin *et al.* (2000) point out, memory may be intact over relatively short periods, but, due to difficulties in the long-term consolidation of information may be impaired over longer intervals. Moreover, the tests used may not be sensitive to subtle impairments in everyday memory functioning experienced by people with epilepsy (Fujii *et al.*, 2000; Sander and Hart, 1997), with a wider cognitive assessment necessary in people presenting with memory difficulties (Thompson and Corcoran, 1992). Tests of remote memory have also been criticised because the nature of the items makes rigorous quantitative assessment more difficult (Gloor, 1997), with difficulties accounting for differences in peoples experiences or exposure to public events (Bergin *et al.*, 2000).

Suggestions for future research

This review has demonstrated the wide range of different factors considered to be related to memory impairments in epilepsy. The many different variables associated with memory deficits have implications for causal explanations of the presence of memory impairments. Future studies are required which attempt to constrain as many of these different variables as possible. Clearly, this is difficult to achieve. However, some possible solutions for reducing the number of confounding variables have been

demonstrated within studies and appear to represent improvements for future research methodologies.

Stricter inclusion criteria to constrain neuropsychological assessment for people who have not undergone surgery to control their epilepsy would remove the possible additional effects of damage caused by the surgery on memory performance. An alternative strategy may be to assess people both before and after surgery to examine the extent to which the surgery may have influenced cognitive deficits. The introduction of studies in which there is a single pathology for the epilepsy (Baxendale *et al.*, 1998a; Oxbury, 2000) is also an important methodological development. Additional categorisation according to all these different epilepsy-related variables is important, and will increase the homogeneity of the groups. However, it will also lead to many small subgroups which will inevitably result in small numbers within the studies (Baxendale *et al.*, 1998a).

The assessment of people prior to starting anti-epileptic medication will control for the possible effects of medication. Studies which have used this approach have developed strict inclusion criteria which required participants to be recently diagnosed adults who were not yet taking anti-epileptic medications (Prevey *et al.*, 1998; Pulliainen *et al.*, 2000). The additional benefits of this approach were the control of variables relating to the epilepsy, such as early age of onset and long durations of epilepsy, as well as the effect of anti-epileptic medication. In studies in which strict inclusion criteria such as these are not possible, selecting participants well stabilised on medication may be another means of constraining the effects, particularly if the types and dosages of medication being taken are controlled for.

While constraining the inclusion criteria for the groups allows more homogenous participant groups, more studies are required in which neuropsychological investigations are carried out for other groups of people with epilepsy, such as those with other seizure types. In addition, future studies must address the relationship between memory and functioning for groups of people with epilepsy who have been overlooked up till now, such as older adults and people with learning disabilities. More consideration needs to be given to the tests included within these studies, with more comprehensive batteries of assessments being required (Goldstein, 1997). Further neuropsychological test development with standardisation and validation is called for to enable cognitive profiles to be supported by neuroimaging and neurophysiological test data (Goldstein and Cull, 1997). These tests need to be included as part of a wider cognitive assessment which takes account of the nature of self-reported memory difficulties and mood as well neuropsychological test performance (Thompson and Corcoran, 1992).

This review of the literature demonstrates that, despite ever expanding research into epilepsy, we still do not know how factors such as the type and duration of epilepsy are associated with the level of reported memory difficulties, and to what extent these may act as mediating factors. This means that we are, as yet, unable to predict the level of difficulty that people may experience as a result of their epilepsy.

Clinical implications

The research outlined within this review has investigated the association between epilepsy and cognitive functioning, with particular regard to memory and the way

that this may inform models of human memory. However, after widespread reports of the presence of memory difficulties, with varying patterns in deficits described, there appear to be very few reports of rehabilitation interventions aimed at ameliorating these reported difficulties. As Thompson (1997) notes, sessions that focus on memory strategies may be useful where people with epilepsy are experiencing memory difficulties. The contribution of memory performance to quality of life in people with TLE would also support psychological interventions and training in memory strategies (Giovagnoli and Avanzini, 2000). The reports of psychological interventions, however, have had a number of methodological limitations and further studies are required to investigate the benefit of these approaches (Ramaratnam *et al.*, 2002). For interventions focused on tackling memory difficulties, techniques need to be drawn from other areas of neuropsychological rehabilitation, such as the brain injury field. Both internal and external memory strategies may be applicable here to compensate for memory difficulties, with the one suggested to be of most value for people with epilepsy being the use of a drug wallet (Thompson, 1997). At the present time the lack of emphasis on rehabilitation strategies for people with epilepsy may be due to the need to first establish the extent of the difficulty. Until some of the discrepancies between the research accounts are overcome it may be difficult to develop clinical research programmes into psychological interventions and memory rehabilitation for people with epilepsy.

Conclusions

Evidence in favour of a memory impairment in epilepsy is variable. The majority of the evidence does suggest that people with epilepsy experience

memory deficits and that the type of information affected is dependent on the hemisphere of epileptic focus, but these findings are not robust and consistent. Further research is called for which controls for the multi-factorial nature of cognitive impairments in epilepsy. From the studies described it appears that there has been a strong tendency to fail to control for many factors related to the epilepsy when recruiting study participants. Within the studies people are only distinguished either on the basis of hemisphere focus for the epilepsy or, slightly better, the brain region identified as the focus, with many of the other influencing variables not accounted for. More accurate measurement of the level of difficulty is also necessary through the use of tests which are more sensitive to the longer-term memory consolidation deficits identified. Future research is required which constrains the possible confounds associated with researching epilepsy variables, such as severity of the epilepsy, or the anti-epileptic medication, in order to provide more meaningful findings.

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Empirical Paper

Remote Memory in People with Temporal Lobe Epilepsy due to Hippocampal Sclerosis

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This paper has been prepared for submission to Brain (see Appendix I for instructions for authors).

Running head: Remote Memory in Hippocampal Sclerosis

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Summary

Epilepsy is associated with a number of impairments in cognitive functioning, with memory being the most widely reported of these. While most studies have focused on new learning, a few investigations have reported significant remote memory impairments in people with temporal lobe epilepsy. In the present study, people with left and right temporal lobe epilepsy due to hippocampal sclerosis were assessed on three measures of autobiographical memory. The tests comprised the Autobiographical Memory Interview, a modified version of the Crovitz test which compared personal memories and memories for public events, and a test of Singular Experiences which assessed familiarity recognition and phenomenological aspects of autobiographical memory. A mild remote memory deficit was found in the left temporal lobe epilepsy group, with no deficit in the right temporal lobe epilepsy group, whose performance was comparable with that of controls. The deficit in the left temporal lobe epilepsy group was equivalent for both personal episodic and public semantic memories and showed a relationship to measures of verbal knowledge and verbal skills.

Introduction

Epilepsy is a neurological condition characterised by recurrent seizures resulting from an abnormal electrical paroxysmal discharge in neurons (Cull and Goldstein, 1997). The focus of the epileptic activity may remain localised in the original site within the brain, or may generalise and spread throughout the cortex. A substantial body of literature now exists which describes the association between neuropsychological functioning and epilepsy. Explanations for the presence of cognitive deficits have included a variety of influencing factors, including the presumed function of the anatomical site of the seizure focus, the extent of the pathology (Baxendale *et al.*, 1998), the frequency and type of seizures, the duration and age of onset of the epilepsy, interictal EEG discharges and the effect of anti-epileptic medication (Oxbury, 2000).

The most common cognitive complaint made by people with epilepsy has been noted to be memory problems (Thompson and Corcoran, 1992). Within epilepsy, the presence of memory deficits is dependent on the particular type of epilepsy, and such deficits are particularly prominent in temporal lobe epilepsy (TLE) (Bergin *et al.*, 2000; Thompson, 1997). Indeed, structures within the temporal lobes are considered to be crucial both for new learning and for storage of recent experiences (Graham and Hodges, 1997) and there have been many reports of memory deficits following damage to this area (Gloor, 1997). Findings from a number of studies have provided evidence to support a material-specificity account of the memory deficits associated with TLE. Damage to the left temporal lobe has been commonly associated with verbal memory deficits (Lee *et al.*, 2002), whereas right temporal lobe damage has been typically associated with non-verbal memory problems (Jones-Gotman *et al.*,

1997). Although many of these studies has involved people who underwent unilateral temporal lobe resection for intractable seizures, which clearly involves additional damage (Helmstaedter and Kurthen, 2001), a similar picture has been found in people with TLE who have not had surgery. A similar specificity of memory impairments has again been reported (Delaney *et al.*, 1980; Giovagnoli *et al.*, 1996; Gleissner *et al.*, 1998; Helmstaedter *et al.*, 1991; Hermann *et al.*, 1987). However, within this group, discrepancies are apparent within the findings, with failures to find a non-verbal memory deficit in people with right TLE (Giovagnoli and Avanzini, 1999), or a verbal deficit in people with left TLE (Goldstein, 1997). Explanations for the discrepancies within these reports have proposed possible differences in the test protocols (Goldstein, 1997), task demands (Saling *et al.*, 1993), and heterogeneity in the groups (Baxendale *et al.*, 1998).

Memory has been extensively studied in people with epilepsy. The majority of studies have explored memory performance through the learning and retention of new information in the verbal or visual memory domains within a short-term and long-term time component (Oxbury, 2000; Thompson, 1997), with comparatively little attention paid to very long-term, or remote, memory (Bergin *et al.*, 2000). The concept of remote memory is considered to be fractionated into two areas (Greene and Hodges, 1996), and comprises very long-term, context-free factual, general semantic memory, and very-long-term context-dependent, personally experienced episodic memory (Kapur, 1999). The distinction between the two types of memory has been supported by evidence of single and double dissociations between remote memory performance on episodic and semantic tasks (Kopelman *et al.*, 1999).

Commonalities in performance across these areas, however, have also been reported (Fujii *et al.*, 2000).

Theories of remote memory processes have largely revolved around two main competing models, the Standard Model and Multiple Trace Theory, to explain the mechanisms of storage and retrieval of long-term episodic and semantic memory. The Standard Model (Squire and Alvarez, 1995) of consolidation draws on evidence from studies of retrograde amnesia which have described the presence of a temporal gradient of memory loss, in which memories recently acquired are more affected than older memories [Ribot's law, (Ribot, 1882)]. Squire and Alvarez (1995) argue that such evidence supports the idea of a memory consolidation process where memory traces initially exist in a fragile state which is dependent on the hippocampal formation. Over time there is a gradual reorganisation of memories by which memory traces are incorporated into a more permanent neocortically-based memory system which is then independent of the hippocampal region.

A different view is proposed by Nadel and Moscovitch (1997) who developed a competing theory, Multiple Trace Theory, to account for the sometimes extensive, flat retrograde amnesia gradients noted in the literature (e.g. Barr *et al.*, 1990; Cipolotti *et al.*, 2001) and which cannot be explained by the Consolidation model. In Multiple Trace Theory it is assumed that the hippocampal formation and the neocortex remain involved in the storage and retrieval of autobiographical episodic memory traces for as long as the memories exist. As episodic memory traces age, they are either lost or form multiple traces in the hippocampal complex through reactivation over time. The traces are dispersed over wider areas of the medial

temporal lobe memory system making them more resistant to disruption (Nadel and Bohbot, 2001).

Research on remote memory is methodologically difficult since one cannot control and easily measure task variables that may influence memory performance (Butters and Cermak, 1986; Gloor, 1997). A small number of studies have examined remote episodic and semantic memory in people with TLE and people who have undergone temporal lobectomy and have highlighted subtle, and in some cases, significant, deficits. The tasks used to assess these forms of memory have largely comprised tests of memory for famous personalities or public events to assess remote semantic memory, whereas studies of remote episodic memory have investigated personal autobiographical memories (Kopelman, 2000).

Autobiographical memory has been noted to be impaired in a heterogeneous group of people with chronic epilepsy using an Autobiographical Fluency Test (Barnett *et al.*, 2000), and for a group of people following temporal lobectomy (Barr *et al.*, 1990). Upton *et al.* (1992) reported that people with epilepsy complain that they cannot remember events from the past and often find the loss of their memories distressing. Interestingly, however, this study found a discrepancy between the subjective report of autobiographical memory difficulties and objective level of memory performance on a standardised test of autobiographical memory with similar performance in individuals with epilepsy and controls. The recall of autobiographical incidents as assessed by the Autobiographical Memory Interview (Kopelman *et al.*, 1990) was decreased in a group of people with unilateral TLE, some of who had undergone temporal lobectomy (Viskontas *et al.*, 2000). A marked impairment of

autobiographical memory was evident which extended back across the participants whole life back as far as early childhood. A difference in performance was observed between the impaired recall of episodic incidents and the ability to answer questions on personal semantic information about past names of teachers and friends, which did not significantly differ from that of controls.

When studies have looked at the relationship between affected hemisphere and remote autobiographical memory performance, the findings are inconclusive. No effect of hemisphere has been reported, for people with TLE (O'Connor *et al.,* 1999), or in people with TLE and temporal lobectomy (Viskontas *et al.*, 2000), although a non-significant trend has been observed in one small group of people with left TLE (Blake, 1999). An effect of side of hemisphere has been found following temporal lobectomy with only people who had sustained a left temporal lobectomy showing impaired performance on questions about individual life events and circumstances (Barr *et al.*, 1990). However, a ceiling effect was noted for the right temporal lobectomy group and controls.

Studies have also examined remote semantic memory in epilepsy. These studies have reported an impairment for people with TLE (Ratti *et al.*, 1992), which has not been found in people with extratemporal epilepsy (Bergin *et al.*, 2000). The effect of side of epileptogenic lesion on remote semantic memory is unclear. Previous studies have reported an absence of a selective deficit in TLE (Bergin *et al.*, 2000; Ratti *et al.*, 1992), although the presence of a deficit in people who had undergone a left temporal lobectomy has been reported (Barr *et al.*, 1990; O'Connor *et al.*, 1999).

The findings of research on very long-term memory functioning in TLE remain conflicting. Some studies of remote memory report a difference between people with TLE and controls, or people with epilepsy originating from outside the temporal lobe, and the extent of a distinction between the performance of people with left or right hemisphere focus remains unclear. There are two main limitations to the research carried out in this area so far. Firstly, the participant samples used in the studies described have been heterogeneous. Some of the studies have grouped people with different locations of their epilepsy, mixed pathologies, pre and post surgery cases, and people with different hemisphere foci. Secondly, as noted earlier, the tests used to assess remote autobiographical memory have been quite insensitive and limited in number and in the range of autobiographical memories tested.

This study recruited more homogeneous groups to enable a more rigorous investigation of remote autobiographical memory in people with TLE. The participants in the study were only people with unilateral hippocampal sclerosis, which is the most common single pathology underlying intractable TLE (Oxbury, 2000). The study was designed to determine whether there was any difference in autobiographical memory between people with TLE and controls, and between left and right TLE pathology. The study also sought to examine whether there were any differences between the different components of remote autobiographical memory; and finally, whether there was any relationship between remote autobiographical memory and clinical neuropsychological variables. Full ethical committee approval was obtained for this study (Appendix II).

Method

Participants

The study focused on 15 individuals with temporal lobe epilepsy (TLE) due to unilateral hippocampal sclerosis attending the Epilepsy Clinics associated with the Wessex Neurological Centre (for details of the recruitment process see Appendix III). Eight participants had seizures originating in the right temporal lobe (5 male, 3 female), and 7 participants had seizures originating in the left temporal lobe (all female). Consecutive patients who fitted the classification criteria were invited to participate by letter from the Consultant Neurologist or Consultant Neuropsychologist. All the participants had seen the Consultant Neurologist and had the nature of their epilepsy determined by clinical, electrophysiological and radiological investigations. In all cases, magnetic resonance imaging had shown unilateral hippocampal sclerosis. None of the participants had episodes of status epilepticus, nor had they undergone surgical intervention for their epilepsy. Potential participants were excluded if there was a history of a major psychiatric illness, alcohol abuse, neurosurgical intervention, head injury or neurological illness other than epilepsy.

Eight control participants with no history of epilepsy were recruited from volunteer panels (3 male, 5 female). They were matched to the participants in the left TLE and the right TLE group for age and IQ (estimated by NART score). There were no significant differences between the groups for Age ($F(2, 20) = .866$, $p = .436$) Years of Education ($F(2, 20) = .1.445$, $p = .259$) or IQ ($F(2, 20) = .2.750$, $p = .080$). Demographic information for all participants is presented in Table 1 (Table 1 near here).

A detailed seizure history was obtained from each participant with epilepsy. This included: age at onset of habitual seizures; duration of epilepsy; presence of febrile convulsions; seizure frequency over the past 6 months; type and severity of epilepsy; and anti-epileptic medication. When seen for the study no participants had suffered any seizure activity during the previous 48 hours. As a group, participants with epilepsy had a mean age of habitual seizure onset of 13.1 years (SD 11.2, range 1.5-37.0), with a mean duration of 24.3 years (SD 12.3, range 8.0-47.0) and a mean frequency of 8.5 seizures per month (SD 9.6, range 0-28). They were taking a mean of 2 anti-epileptic medications (SD 0.6, range 1-3). The only significant difference between the groups was in the duration of the epilepsy, with the left TLE group having a significantly longer duration ($t(13) = 4.4$ (equal variance not assumed), $p = .002$). The types of seizures participants experienced included: simple partial seizures; complex partial seizures; secondary generalized seizures; and, generalized tonic clonic seizures (Table 2 near here).

Informed consent was obtained from all participants (Appendix IV, information sheets Appendices V and VI). All participants were reimbursed for their travel expenses. According to custom and practice, an honorarium was offered to control participants.

Materials and procedure

1. Background neuropsychological testing

A series of neuropsychological assessments was completed by participants with epilepsy in order to assess variables which may be associated with performance on autobiographical memory tests.

This series of tests, with the exception of the Wechsler Adult Intelligence Scale III Letter-Number Sequencing Test (Wechsler, 1997), was usually administered as part of routine clinical practice in the Epilepsy Service. Where it was necessary to complete this assessment, the tests were administered in a separate session lasting three hours, with breaks, as necessary. The neuropsychological tests comprised the following: National Adult Reading Test (Nelson, 1991); Adult Memory and Information Processing Battery (AMIPB) (Coughlan and Hollows, 1985) Story Recall and Design Learning subtests; Recognition Memory Test (Warrington, 1984) Faces subtest; Doors and People Memory Test (Baddeley *et al.*, 1994) Names Recognition subtest; Verbal Fluency (Lezak, 1995); Category Fluency (Lezak, 1995); Speed and Capacity of Language-Processing Test (SCOLP) (Baddeley *et al.*, 1992) Sentence Comprehension; Graded Naming Test (McKenna and Warrington, 1983); Rey Complex Figure Copy (Meyers and Meyers, 1995); Wechsler Adult Intelligence Scale III (WAIS-III) (Wechsler, 1997) - Similarities, Arithmetic, Information, Digit Symbol, Letter Number Sequencing, Block Design, Matrix Reasoning; Modified Card Sorting Test (Nelson, 1976); Brixton Spatial Anticipation Test (Burgess and Shallice, 1997).

Table 3 provides details on the neuropsychological test performance for the participants with epilepsy[1]. The neuropsychological data were analysed using independent *t* tests, with the exception of the category score from the Modified Card Sorting Test which was analysed using a Mann Whitney U test as it did not meet the assumptions of normal distribution required for parametric tests. Significant

1 For the left TLE group n=6 as neuropsychological test data were not available for 1 participant.

differences were found between the participants with left or right TLE, on the WAIS III Arithmetic subtest ($t(11) = -2.363$, $p = .038$) for which the right TLE participants achieved a higher mean score, and the Brixton Spatial Anticipation test error score ($t(12) = 2.265$, $p = .043$) on which the right TLE group scored significantly less mean errors. No significant differences were found between the groups on the other tests: NART FSIQ ($t(13) = -.812$, $p = .432$); WAIS-III Similarities ($t(12) = -.522$, $p = .611$); WAIS-III Information ($t(12) = -.553$, $p = .590$); WAIS-III Digit Symbol ($t(12) = -1.491$, $p = .162$); WAIS-III Letter Number Sequencing ($t(12) = .180$, $p = .860$); WAIS-III Block Design ($t(12) = -.760$, $p = .462$); WAIS-III Matrix Reasoning ($t(12) = -1.465$, $p = .169$); AMIPB immediate Story Recall ($t(12) = -.015$, $p = .988$); AMIPB delayed Story Recall ($t(12) = -.151$, $p = .882$); AMIPB immediate Design Learning ($t(12) = -.539$, $p = .600$); AMIPB delayed Design Learning ($t(12) = -1.012$, $p = .332$); AMIPB Design Leaning B ($t(12) = -1.309$, $p = .215$); Recognition Memory Test Faces ($t(12) = .379$, $p = .712$); Doors and People Test Names Recognition ($t(11) = -.627$, $p = .544$); Verbal Fluency ($t(12) = -.581$, $p = .572$); Verbal Fluency Adjusted ($t(12) = -.461$, $p = .653$); Category Fluency ($t(12) = -.709$, $p = .492$); SCOLP Sentence Completion ($t(12) = .326$, $p = .750$); Graded Naming Test ($t(12) = -.844$, $p = .415$); Rey Complex Figure ($t(12) = -.228$, $p = .823$); Modified Card Sorting Test Errors ($u(12) = 18.500$, $p = .491$) (Table 3 near here).

2. Experimental test procedures

Participants completed three autobiographical memory tests including free recall, cued recall and an autobiographical recognition memory task. These tests took 2 hours to complete and were administered in a single session (for test protocol see Appendix VII). The tests are described below:

1. The Autobiographical Incident component of the Autobiographical Memory Interview (Kopelman *et al.*, 1990) – This is the only published standardised measure of autobiographical memory. It asks people to describe memories acquired at different periods of time (childhood, early adulthood and recent past). This test distinguishes between the two areas of autobiographical memory, with questions which ask about semantic details (e.g. name of school, friends etc.) and questions relating to autobiographical episodes (e.g. first day at work). Performance across the different periods can be compared for degree of detail, to ascertain whether there are any differences in the level of recall. The Autobiographical Memory Interview has previously been used in other studies of remote autobiographical memory in epilepsy (Bergin *et al.*, 2000; Upton *et al.*, 1992). The personal semantics component of the test was not given as this section of the test has been found to be less sensitive than that dealing with the recall of incidents (Kapur, 1999; Viskontas *et al.*, 2000). In addition, time constraints limited the number of autobiographical memory tests that could be administered.

The administration of the autobiographical incidents questions followed the procedure outlined given in the test manual, with the exception of question 7, which asks for an incident from the present hospital or institution. This was modified according to the test instructions, to allow for questioning in an outpatient context rather than, as originally designed, for inpatients. Each answer was scored as 0, 1, 2, or 3 based on the descriptive richness and specificity in time and place of the response. Standard scoring rules for the test were employed

and included a set of sample responses and scores. The test produces subtotals for the time periods of childhood, early adulthood and recent life, with a maximum score of 9 for each period, as well as a total score.

2. Modified Crovitz Test (Kapur, 2000) (Appendix VIII). This test for assessing autobiographical episodic memories from people's pasts was originally devised by Galton (1883) and was adapted by Crovitz and Shiffman (1974). In the original Crovitz technique, as described by Crovitz and Schiffman (1974) individuals are presented with a cue word (typically concrete nouns) and asked to try and recollect a personally experienced incident that could be related to the cue word. If a general rather than a specific recollection is given the person is encouraged to try to recall a specific incident. Various forms of this technique have been described in a range of published studies (e.g. Baddeley and Wilson, 1986; Crovitz, 1986; Williams and Broadbent, 1986; Zola-Morgan *et al.*, 1983).

   A list of 12 common English nouns that could potentially evoke either an episodic (personally experienced) or semantic (public event) memories was read out to participants. They were asked to describe either a personally experienced event or a news event that had occurred in a particular time and place, in as much detail as possible (see Appendix VIII for a list of the nouns used). The conventional method of scoring these responses adheres to the guidelines outlined by Crovitz and Shiffman (1974), with responses scored on a 0-3 scale. Criticisms have been levelled at the insensitivity of this scoring procedure (Nadel *et al.*, 2000), and recently a more sensitive 0-5 scale has been proposed (Graham and Hodges, 1997) which allows a greater discrimination of multiple and single

experiences, and the amount of detail given. Within this study responses were scored according to both methods (Appendix IX). This comparison demonstrated the more recent 0-5 scale to be more sensitive, with greater variation in the scores, and to also have better inter-rater reliability (see results section) and it was therefore decided to adopt the 0-5 scoring system when reporting scores for the Modified Crovitz test.

The Crovitz cued recall test has been used in other studies of autobiographical memory (Baddeley and Wilson, 1986; Moscovitch and Melo, 1997; Williams and Broadbent, 1986), albeit with different stimulus items, and some differences in test protocol. Obtaining both personal and public memories using the Modified Crovitz procedure with identical cue words also enables a comparison of remote autobiographical memory performance and remote public semantic memories on a recall test which is matched for task demands. A similar study design has been reported by Moscovitch and Melo (1997) who used personal and historical cue words to compare episodic and semantic recall, but in this study different words were used for the two versions.

Participants' answers were recorded as close to verbatim as possible and were also tape recorded so that responses could be confirmed later. Following the scoring, the tapes were erased. A single rater scored all of the questions. To ensure adequate consistency was present in the marking an independent rater, who was blind to group membership and the original ratings, scored 25% of the Autobiographical Memory Interview and Modified Crovitz tests. Inter-rater reliability was calculated using correlations and crosstabulation tables (see results section).

3. Abbreviated Singular Experiences Test (Appendix X) - This measure was designed specifically for the study and is a shortened form of the Singular Experiences Test (Kapur, 2001) (for details of how this measure was modified see Appendix XI). This measure assesses autobiographical recognition memory and is similar to the Life Events Inventory described by Garry *et al.* (1996). This test was included to test autobiographical memory using a task with reduced retrieval demands than other tests such as the Autobiographical Memory Interview or the Modified Crovitz test. Participants were asked whether or not they had experienced a number of life events, and to provide further information on features of their recollection. The test was designed to provide information on phenomenological aspects of autobiographical memory by obtaining ratings of the degree to which participants could 'relive' or 'mentally time travel' to the event in question.

This methodology is similar to that used in other neuropsychological studies of autobiographical memory that have provided strong retrieval cues through the use of photographs or event descriptions (e.g. Hodges and McCarthy, 1993; Kitchener *et al.*, 1998) or through details from informants (e.g. Cermak and O'Connor, 1983; Evans, 2001; Stringer, 1996).

The Abbreviated Singular Experiences Test was administered orally and required participants to indicate which of a list of 40 experiences they had experienced. For each positively identified experience, participants were asked whether this had occurred once or more than once, and whether they could single out a

specific occasion when this event happened. If participants were able to identify a specific incident they were then asked to rate their memory for the experience, in terms of the amount of detail and imagery they could recall from three verbal descriptions. The amount of detail was rated on a three point scale ranging from 'know it happened' to 'detailed' (Appendix XII), while the level of imagery was rated on a three point scale from 'cannot picture' to 'clear' (Appendix XIII). Finally, participants were asked to give an approximate date or estimation of their age when the event took place. The Abbreviated Singular Experiences test produced 6 measures. These were i) the number of events experienced (max = 40), ii) the number of specific events recalled (max = 40), iii) the proportion of specific events recalled from the number of events experienced, which will hereafter be referred to as proportion specific events, iv) the mean memory rating, v) the mean imagery rating, and vi) the time periods from which the memories were recalled.

Statistical analyses

The data were analysed using SPSS 10.0 for Windows (2001). For the statistical analysis an alpha level of 0.05 was used throughout. One-Sample Kolomogorov-Smirnov tests were performed on all the results to establish whether the assumptions of a normal distribution to the data were supported (see Appendix XIV). Where normal distribution was established the data were analysed by means of a 3 (groups: left TLE, right TLE, and controls) by 3 (time periods: childhood, early adulthood, and recent life) repeated measures analysis of variance (ANOVA). To establish that there were no differences between the independent variables, one-way ANOVA and independent *t* tests were used.

Where data did not satisfy the assumptions necessary for a normal distribution, where possible, scores were transformed using square root or logarithm transformation, as appropriate. Where ceiling or floor effects were evident in the data, giving rise to a high frequency of zeros or maximum scores, and transformations were not possible, nonparametric statistics Mann-Whitney U tests or Kruskal-Wallis tests were used. The inter-rater reliability data were not normally distributed and were analysed using Spearman's Rho and Crosstabulation tables.

To allow comparative analyses between the autobiographical memory measures and the neuropsychological test results scaled score data were used. This was not always available, with some tests giving only age related percentiles (e.g. AMIPB). In these instances a scaled score was derived using means and SD from published norms. Correlations were carried out between tasks considered to assess verbal and visual memory, language, naming and semantic information, and executive function.

In order to examine the dating of the episodes recalled for the Modified Crovitz test and Abbreviated Singular Experiences test, a procedure outlined in Zola-Morgan *et al.* (1983) was adopted. The number of memories recalled in each time period was calculated as a percentage of the total number of memories elicited from each participant. It was, therefore, possible to ascertain the presence of any temporal gradient in the memory loss shown by the participant, independently of the total number of memories recalled. On the Personal memories version of the Modified Crovitz test and the Abbreviated Singular Experiences test, the time periods used were similar to those described in the Autobiographical Memory Interview and

consisted of childhood (0-18 years), early adulthood (19-35 years), and recent life (last 5 years). In view of the age distribution of participants, some memories encompassed two of these periods, i.e. if the person was 25 and was recalling an event that had happened two years ago. In these instances, if the memory was reported to have happened within the last five years, it was considered to be within the recent life time period, regardless of whether or not it also fitted another category. For the Public memories version of the Modified Crovitz test, three time periods were used, which were defined as: memories recalled from the current and previous year; 2-5 years ago; and 6 or more years ago. It was not possible to divide this last time period into more discrete time periods due to the small number of responses which fell into this category.

Results

Inter-rater reliability

One-sample Kolmogorov-Smirnov tests revealed that the inter-rater data were negatively skewed. The data could not be successfully transformed and so nonparametric correlations were used to evaluate the inter-rater reliability for responses scored by two raters. On the Autobiographical Memory Interview, the resulting Spearman's Rho correlation was .80 (p = .000) which is just below that reported in the Autobiographical Memory Interview test manual (.83-.86). For the Personal memories component of the Modified Crovitz test a Spearman's Rho correlation coefficient of .83 (p = .000) was achieved. The scores for the Public memories version of the Modified Crovitz test were also significantly correlated with a coefficient of .79 (p =. 000) (Crosstabulation tables for the two measures are shown in Appendix XV).

Autobiographical memory measures

Autobiographical Memory Interview: On the Autobiographical Memory Interview there was a significant main effect of time period $F(2, 20) = 14.9$, $p = .000$ but no main effect of group $F(2, 20) = 0.481$, $p = .625$ and no significant interaction $F(2, 20) = 1.030$, $p = .404$ (Figure 1 near here).

Modified Crovitz Test - (a) Personal Memories: All three groups produced memories for most of the words on the Personal memories subtest of the Modified Crovitz. A Kruskal-Wallis test revealed no significance difference between the groups in the number of memories recalled (Chi-Square (2) = 2.9, $p = .230$). In terms of the level of detail and richness of the memories recalled there was a significant difference in mean score between the groups on the Personal memories component of the Modified Crovitz when analysed using a one-way ANOVA ($F(2, 20) = 6.2$, $p = .008$) (see Table 4). A post hoc multiple comparisons analysis using the Bonferroni test revealed the left TLE group to significantly differ from the healthy control group ($p = .007$) (Table 4 near here).

There was a significant variation between participants in their ability to assign dates to their personal memories ($F(2, 20) = 4.746$, $p = .021$), with the left TLE participants able to assign dates to 73% of their personal memories, significantly less ($p = .022$), than the healthy controls who assigned dates to 97% of their memories. The right TLE participants did not significant differ from control participants and were able to assign dates to 80% of their memories. Figure 2 shows the memories which were successfully recalled on the Personal memories component of the

Modified Crovitz, classified according to time period. There was a significant effect of time period ($F(2, 20) = 6.5$, $p = .003$) but no main effect of group ($F(2, 20) = 2.6$, $p = .097$) and no interaction ($F(2, 20) = 0.8$, $p = .506$) (Figure 2 near here).

Modified Crovitz Test - (b) Public Memories: On the Public memories component, the mean number of memories recalled was lower than for the Personal memories although a Kruskal-Wallis test revealed no significance difference between the groups (Chi-Square (2) = 5.2, $p = .076$). On the scoring of the memories there was a significant difference between the groups ($F(2, 20) = 9.3$, $p = .001$). Multiple comparisons revealed that the left TLE group differed significantly from the both the right TLE group ($p = .009$) and the control group ($p = .002$).

In the case of dating the Public memories recalled in the Modified Crovitz test all the groups failed to be able to date a number of the Public memories that they recalled, and there was no significant difference between the groups ($F(2, 20) = 2.7$, $p = .090$). The left TLE group provided a date for 70% of their memories, and the right TLE group and healthy controls both dated 84% of the memories. To discover whether there was a difference between the groups in their recall for the different time periods, a repeated measures ANOVA was conducted. This analysis found a main effect of time period ($F(2, 20) = 18.1$, $p = .000$) and group ($F(2, 20) = 4.9$, $p = .018$) but no interaction effect ($F(2, 20) = 0.7$, $p = .624$) (see Figure 3). A post hoc Bonferroni test revealed that the left TLE group performed significantly differently from the right TLE group ($p = .045$) and the control group ($p = .031$), while the right TLE group did not significantly differ from the control group (Figure 3 near here).

Abbreviated Singular Experiences Test: For this test[2] there was a significant difference between groups for the number of experiences identified ($F(2, 19) = 4.0$, $p = .037$), and the number of specific occasions identified ($F(2, 19) = 7.2$, $p = .005$), with the left TLE group being significantly different from the control group on a post hoc Bonferroni test ($p = .034$). However, when the proportion specific events was computed, to control for possible differences in the total number of experiences people had, there was no significant difference between groups ($F(2, 19) = 2.6$, $p = .100$) (Table 5 near here).

For the memory and imagery ratings of the singular experiences recalled, a series of univariate ANOVAs were carried out. These analyses found no differences between the groups for the three memory ratings of 'know it happened' ($F(2, 19) = .355$, $p = .706$), 'patchy recollection' ($F(2, 19) = .296$, $p = .747$) and 'detailed recollection' ($F(2, 19) = .501$, $p = .614$). The differences between the imagery ratings were also not significant for 'cannot picture image' ($F(2, 19) = .329$, $p = .724$), 'can vaguely picture' ($F(2, 19) = .652$, $p = .532$), and 'can clearly picture' ($F(2, 19) = .150$, $p = .861$) (Figure 4 near here).

To allow comparison of the age periods from which the memories were recalled, they were grouped in accordance with the Autobiographical Memory Interview criteria as outlined earlier. On this analysis there was no main effect of time period ($F(2, 19) = 0.827$, $p = .445$), or of group ($F(2, 19) = 0.3$, $p = .723$) and no interaction effect ($F(2, 19) = 0.9$, $p = .497$) (Figure 5 near here).

[2] Data were available for 19 participants on this test as one participant in the left TLE group had to discontinue the test due to a seizure.

The effect of age of onset of epilepsy

To explore the effect of age of onset of seizures on autobiographical memory, two subgroups of participants with epilepsy were formed on the basis of age of onset, irrespective of epilepsy focus. These groups followed the same criteria for age of onset as that used by Viskontas *et al.* (2000) with an early onset group consisting of participants whose habitual seizures began on or before the age of 5, whilst the late onset group comprised participants whose epilepsy had begun on or after the age of 18. As can be seen in Table 6 there were no significant differences between the two groups for the Autobiographical Memory Interview time periods of Childhood ($t(8) = 1.066$, $p = .318$), Early Adult ($t(5.882) = 1.095$ (equal variance not assumed), $p = .316$), or Recent Life ($t(8) = 1.414$, $p = .195$). No significant difference between the age of onset groups was also found for the Modified Crovitz test recall scores for both the Personal memories ($t(8) = -1.698$, $p = .128$) and the Public memories ($t(8) = -2.186$, $p = .060$), or for The Abbreviated Singular Experiences test when the proportion of events recalled as specific by the two groups was compared ($t(7) = -1.795$, $p = .116$) (Table 6 near here).

The effect of duration of epilepsy

As has been noted, the two epilepsy groups were significantly different in terms of the duration of the epilepsy, with the left TLE group having a longer mean duration. When the autobiographical memory test performance for the two groups was correlated with epilepsy duration Pearson correlation coefficients revealed significant correlations between the left TLE group and the early adult subtotal (-.835), recent life subtotal (-.800) and the Autobiographical Memory Interview total (-.887). For the right TLE only the Abbreviated Singular Experiences test proportion specific

events was significantly related (-.860). Epilepsy duration was not significantly correlated with the Modified Crovitz test scores for either group.

The relationship between the neuropsychological test results and performance on the experimental autobiographical memory measures

Performance on the autobiographical memory tests was correlated with performance on certain neuropsychological tests which could be considered to be associated with remote memory performance (see Table 7 for left TLE, and Table 8 for right TLE). The scores were correlated using Pearson's correlations coefficients. As can be seen from the tables the relationship between the measures varied between the groups. For the left TLE group significant correlation coefficients were found between the delayed visual memory test and the early adult total of the Autobiographical Memory Interview and the Public memories version of the Modified Crovitz test. Naming, semantic knowledge, as assessed by the Similarities and Information subtests from the WAIS-III, and executive function, as assessed by the Brixton Spatial Anticipation test, were also significantly correlated with the early adult total of the Autobiographical Memory Interview.

For the right TLE group, category fluency and the Speed of Comprehension test were significantly correlated with the early adult total of the Autobiographical Memory Interview. The measure from the Abbreviated Singular Experiences test did not show any correlations with the neuropsychological measures for either group (Tables 7 and 8 near here).

Discussion

Summary of findings

This study assessed remote memory in people with TLE due to hippocampal sclerosis. It found a mild remote autobiographical memory deficit. However, the presence of this deficit depended on the test used, with an impairment being present on the Modified Crovitz test, but not on the Autobiographical Memory Interview or the Abbreviated Singular Experiences test. Secondly, a significant difference was found between the groups, with the left TLE group showing a deficit, whilst there was no difference between the right TLE group and controls. Thirdly, the observed deficit in remote memory was not selective for autobiographical episodic memory, but was also evident on the semantic memory component of the Modified Crovitz test. Fourthly, duration of the epilepsy did not affect performance on the Modified Crovitz test. Finally, performance on the autobiographical memory tests was significantly correlated with neuropsychological tests of verbal functioning for both groups, with an association also found for a visual memory test in the left TLE group.

The discrepancy between performance on the Autobiographical Memory Interview and the Modified Crovitz test supports the argument that tests traditionally used to assess autobiographical memory may be insensitive to the subtle level of impairment that may be associated with selective hippocampal lesions found in people with epilepsy (Nadel *et al.*, 2000). Even where some level of autobiographical recall is achieved, a careful analysis reveals that memories may not be as detailed as those offered by controls (Nadel *et al.*, 2000). This holds true for the present study, where no impairment was found on the Autobiographical Memory Interview, but a

significant deficit was evident on the Modified Crovitz test using a detailed 0-5 scoring system.

For the Abbreviated Singular Experiences test there was a significant difference between the left TLE group and controls on the number of events and singular experiences that participants could identify, although this difference did not remain once the proportion of specific events which could be recalled was computed. This represents a more valid measure which taps the ability to recall singular, episodic, events while controlling for differences in the number of events to which people have been exposed. The group differences in the number of events identified could be considered to reflect a difference in life experiences between the groups, with the participants with epilepsy leading more restricted lives, as a result of their seizures (Sander and Hart, 1997). The presence of seizures, however, cannot be the whole explanation, as the right TLE group did not show significant differences in their level of exposure to events from controls despite their epilepsy. One significant difference between the two epilepsy groups was in the duration of their epilepsy, with participants with left TLE having significantly longer epilepsy durations. Thus, while seizures per se may not be restrictive, a long history of seizures, which frequently started in childhood, may have contributed to a reduced exposure to events. The ratings made on the Abbreviated Singular Experiences test represented an attempt to explore the groups' ability to 'mentally time travel'. This phenomenon has been considered to be a critical component in the ability to recall episodic memories. Comparable levels of ratings were achieved for the amount of detail and imagery components of this aspect of recollection, suggesting that a deficit in mental time travel is not associated with unilateral hippocampal pathology.

There was no evidence of temporally graded remote memory loss in the test scores of any of the autobiographical memory tests. Both participants with epilepsy and healthy controls demonstrated a recency effect (Rubin *et al.*, 1986), with better retrieval for more recent memories than for remote ones on the Autobiographical Memory Interview and Modified Crovitz test. The distribution of time periods from which the memories were retrieved for the Abbreviated Singular Experiences test did not show such an effect and the distribution of memories was in fact much more consistent across all three time periods, with the exception of a peak for the right TLE group for memories from childhood. This peak may be explained by a phenomenon known as the 'reminiscence bump' (Jansari and Parkin, 1996), in which respondents show preferential recall for memories from the period of 10-30 years. Such a bump has been explained in part by the many and varied life experiences that occur during this time period. The absence of this peak in the left TLE group may be related to the early onset of their epilepsy, as mentioned above. However, the absence of this in control participants is less easy to explain. It is possible that the inclusion of all recent memories from the last 5 years into a separate category within the autobiographical memory tests may have reduced the extent to which this was evident. Therefore, the young mean age of the groups meant that memories that would have fallen within the age distribution for the reminiscence bump were instead classified as 'recent memories'.

Relationship to published findings on remote memory

When the present findings are compared with those described in the published literature, the results do not support the marked impairment in personal episodic

memory claimed by Viskontas *et al.* (2000) who used the Autobiographical Memory Interview with a heterogeneous group of people with unilateral TLE or temporal lobectomy. Moreover, the relationship between affected hemisphere and mild remote memory impairment found in the present study was not found in other studies for autobiographical information (O'Connor *et al.*, 1999; Viskontas *et al.*, 2000) or for semantic information (Bergin *et al.*, 2000; Ratti *et al.*, 1992). The findings of this investigation are more consistent with that reported by Barr *et al.* (1990) who found impairments for both autobiographical and semantic memory in people who had undergone a left temporal lobectomy for intractable temporal lobe epilepsy.

The presence of a significant deficit in the left TLE group on the Modified Crovitz test but not on the Abbreviated Singular Experiences test is consistent with observations that more extensive structure and cueing can increase individual's level of autobiographical recall when a deficit has been observed on less structured recall tests (Cermak and O'Connor, 1983; Kitchener and Hodges, 1999; MacKinnon and Squire, 1989). It has been suggested that since most remote memory tests adhere to a verbal questionnaire format, the presence of a deficit in people with left temporal lobe damage may reflect a material-specific deficit in verbal retrieval (Barr *et al.*, 1990). In the present study, a significant correlation was found in the left TLE group between the early adult section of the Autobiographical Memory Interview and performance on the Graded Naming test, the Similarities and Information in the WAIS-III, and a test of executive function. A significant correlation was also found between visual delayed memory and the early adult section of the Autobiographical Memory Interview and the Public memories component of the Modified Crovitz test perhaps indicating some visual imagery component within the autobiographical

memory tasks. In the right TLE group, the verbal tasks of category fluency and speed of comprehension were significantly correlated with the early adult section of the Autobiographical Memory Interview. The association with verbal measures may reflect a verbal retrieval problem in the responses given. However, the absence of a consistent correlation across both the Autobiographical Memory Interview and the Modified Crovitz test, both of which have significant verbal retrieval requirements is difficult to explain. Measures of verbal memory have been found to be strong predictors of performance on semantic memory for past events (Bergin *et al.*, 2000), but this was not found in the current study.

Implications for models of long-term memory consolidation

How can the finding of a mild remote memory deficit in people with left TLE be explained when the temporal lobes are considered to be so vital for long-term processes of storage, either for a temporary period, according to the Standard Model, or permanently, according to the Multiple Trace theory? According to the Standard Model, people who have damage to the hippocampal system, such as those with hippocampal sclerosis, would be predicted to show a temporal gradient on tests of remote memory, with no distinction between autobiographical and semantic memory performance. No evidence of a temporally graded memory loss was found in the study, either for personal or public memories, with both being equally affected.

However, the concordant findings of a deficit for both autobiographical and semantic memory on the Modified Crovitz test also cannot easily be accounted for either by the Multiple Trace Theory. This would have predicted a more marked autobiographical episodic memory deficit and a difference between personal and

public recall on the Modified Crovitz. The absence of a distinction in performance between these two domains has been found in other studies and has led to the questioning of the separation of episodic and semantic memory in terms of hippocampal function (Barr *et al.*, 1990; Bergin *et al.*, 2000; Helmstaedter and Kurthen, 2001). One explanation for the similar levels of impairment shown across the two domains in the left TLE group may be the presence of a narrative structure within the properties of both types of memory. Moscovitch and Melo (1997) found no difference between performance on personal and historical memories using a version of the Crovitz and argued that the crucial distinction may lie not between episodic and semantic memory, but between memories which have a narrative structure and those which do not. Thus, the semantic questions in the Modified Crovitz test may involve the same strategic retrieval processes as personal episodic memories.

The difficulty in applying either of the models of memory consolidation to the current data may be explained in three possible ways. Firstly, hippocampal sclerosis is a developmental abnormality leading to discrete lesions that primarily affect an area of the hippocampus known as the dentate gyrus. This has been proposed to be less important to memory than the surrounding areas of the hippocampus, and this may explain the absence of a significant deficit (Briellmann *et al.*, 2002; Nadel *et al.*, 2000). Secondly, in the case of developmental lesions, Graham and Hodges (1997) have suggested that there may be extensive neural reorganisation in people with intractable epilepsy from an early age, even for those people in whom the epilepsy does not develop until adulthood, and that this would limit the extent to which memory may be affected. Thirdly, the studies which have reported significant levels

of retrograde amnesia have, for the most part, reported this for people with bilateral medial and lateral temporal lobe damage (Cippolotti *et al.,* 2001; Kopelman, 2000) following an acute illness rather than for unilateral damage.

Limitations of the study

Whilst this study had a number of strengths there were several methodological limitations. The size of the sample used in the study should, ideally, have been larger but the strict exclusion criteria to ensure group homogeneity meant that the groups were relatively small. Despite the best efforts to achieve homogenous groups there was a significant difference in epilepsy duration between the two groups. The possible effects of this could not be controlled within the small groups, with all the participants in the left TLE group having a duration of over 20 years, whilst only one of the right TLE group had experienced epilepsy for that length of time. Duration was not however, significantly related to performance on the Modified Crovitz test for either group so it remains unclear whether this factor was important in the present study.

The spread of ages within the sample led to some methodological problems on the autobiographical memory tests. Although the two epilepsy groups and control participants were matched as closely as possible for age, age-related factors do arise for particular tests which tap recollection of specific events, such as first job on the Autobiographical Memory Interview, as this may have been a recent event for the younger participants.

In future studies, it may be worth considering the inclusion of a non-temporal lobe epilepsy group of participants. The inclusion of a group of individuals with a different focus to their seizure pathology, such as people with extratemporal or primary generalised seizures, has been used in other studies and would control for the secondary effects of the seizures, anti-epileptic medication, and psychosocial restrictions in life experiences. For example, it could be hypothesised that if a person has had epilepsy since their early adulthood this may have curtailed possible experiences through choice of job or driving. In this respect, a group drawn from a hospital population may also represent a more appropriately matched control group. Individuals recruited from non-neurological units within the hospital, such as people with asthma, may provide some degree of comparison of the effect of living with a chronic health condition. Due to limited numbers in the study, it was not possible to explore the effect of seizure frequency and type, which have been hypothesised to be predictors of the efficacy of remote memory (Bergin *et al.*, 2000).

The scoring for the Autobiographical Memory Interview and Modified Crovitz test questions posed difficulties, due to the subjective element in the scoring. Despite guidelines scoring was not found easy to operationalise. Tape recording the interviews in order to allow for an assessment of inter-rater reliability reduced the possibility of considerable differences between the way the tests were scored but the constraints of the study prevented all the responses being scored by two independent raters or carried out by someone blind to group membership.

The design of the Modified Crovitz test and the Abbreviated Singular Experiences test allowed all the events to be recalled from any period of the participant's life. This

meant that potentially all recollections could have come from one time period, particularly in the case of the Modified Crovitz test where recollections could be clustered around a common theme, with one memory triggering off another one from the same period (Baddeley and Wilson, 1986). Within the present study, there was a tendency for memories to be offered from more recent time periods but it is not possible to explain why this was so and whether they were easier to recall, or were cued by an earlier memory that was recalled. Similarly, the number of memories sampled can be a problem. While the Autobiographical Memory Interview asks for memories from three distinct time periods, only a small number of memories are required and testers can sometimes feel that respondents are recalling their "favourite" memories (Blake, 1999) which are well rehearsed. Furthermore, the test does not assess remote autobiographical memory on a year-by-year basis and large sections of an individual's life are still not assessed with the result that deficits could go undetected (Kapur *et al.*, 1989; Spreen and Strauss, 1998). This has been observed to be a particular problem when testing older people since the period between mid 30s to recent times (taken as the last five years) is usually not assessed and could, potentially, span 30 or more years (Graham and Hodges, 1997). One way to overcome these difficulties is to apply the Crovitz test procedure in the usual way, but to obtain memories from distinct time periods (Graham and Hodges, 1997).

Future studies building on the research may wish to consider additional factors such as mood, since depressed mood has been identified as a predictor of poor memory performance in people with epilepsy (Corcoran and Thompson, 1993), and media exposure, to control for this when examining people's level of recollection for public events (Kapur *et al.*, 1999) when carrying out studies of remote memory.

Clinical implications for the management of remote memory loss

This study does not support the view that a significant impairment of remote autobiographical memory is an inevitable consequence for people with TLE with hippocampal sclerosis. Nevertheless, some degree of mild impairment was evident in a number of participants, and clinicians that work with these clients may need to be aware that clients may occasionally report these forms of difficulty. Rehabilitative strategies through the encouragement of the use of diaries and photograph albums may offer alternative means of recording events so that they can be recalled at a later date. Family members may also be able to assist through the creation of memory books which could contain photographs and recollections for the missing parts of childhood or early adult life as has been described in interventions for people with dementia (Spector *et al.*, 2000), or brain injury.

Implications for future research

The current study's findings provide some useful information for the development of improved autobiographical memory tests. Future tests need to make use of a more sensitive scoring system, either through the use of more extensive graduations, as used here, or by scoring for the number of details provided for each cue (Nadel *et al.*, 2000), or with the use of multiple scales (Zola-Morgan *et al.*, 1983). Memories need to be obtained from across an individual's entire life span by the adoption of a methodology that uses several different time periods (e.g. Graham and Hodges, 1997).

The single-choice recognition memory format used in the Abbreviated Singular Experiences test could be usefully extended to include a forced-choice recognition testing of autobiographical memory. Investigations of such autobiographical recognition memory, where test items are obtained from interviews with carers (Evans, 2001), may have implications for the benefit of retrieval cues in any rehabilitation interventions with individuals experiencing remote memory loss and may help to inform models of long-term memory consolidation.

Conclusions

In summary, this study has shown that in people with left TLE secondary to hippocampal sclerosis a mild deficit in remote memory can be found. This deficit encompasses both episodic autobiographical memory and public semantic memory to a similar degree. The findings of this investigation suggest that complaints of long-term autobiographical memory difficulties in people with epilepsy should not be dismissed, but that improved, more sensitive, methods of testing are required to provide an accurate representation of this aspect of memory in people with neurological impairments.

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List of tables and figures

Table 1. Demographic information for participants with epilepsy and controls

	Participants with epilepsy						Control participants		
M (SD), range	LTLE *N* = 7			RTLE *N* = 8			*N* = 8		
Age	41.6	(12.9),	24-60	33.6	(10.6),	19-47	36.3	(12.0),	22-53
Years of education	11.4	(1.2),	10-13.5	11.5	(1.4),	9-13	12.7	(2.2),	10-16
NART Full scale IQ	93.1	(9.6),	74-103	96.8	(7.6),	86-112	103.4	(8.7),	96-120
N (%) right handed	6	(86%)		7	(88%)		6	(75%)	
N (%) Left handed	1	(14%)		1	(12%)		2	(25%)	

Note: LTLE = Left temporal lobe epilepsy, RTLE = Right temporal lobe epilepsy

Table 2. Seizure details for participants with epilepsy

	Participants with epilepsy					
M (SD), range	LTLE *N* = 7			RTLE *N* = 8		
N (%) with febrile convulsions	2	(28.6%)		4	(50%)	
Age of onset	7.6	(6.8),	1.5-20.0	17.9	(12.5),	1.5-37.0
Duration of epilepsy in years	34.1	(10.3),	22.0-47.0	15.7	(5.6),	8.0-24.0
Monthly frequency of seizures	9.0	(12.8),	0-28.0	8.3	(8.7),	0.5-25.0
Number of anti-epileptic medications	2.1	(0.7),	1-3	1.9	(0.4),	1-2

Note: LTLE = Left temporal lobe epilepsy, RTLE = Right temporal lobe epilepsy

Table 3. Neuropsychological test scores for participants with epilepsy

	Participants with epilepsy					
M (SD), range	LTLE $N = 6$			RTLE $N = 8$		
General intellectual function						
NART Full Scale IQ	93.7	(10.4),	74-103	96.8	(7.6),	86-112
WAIS-III						
Similarities (33)	19.2	(5.5),	13-27	22.1	(13.0),	11-51
Arithmetic (22)	9.8	(2.2),	7-12	13.6	(3.2),	10-18
Information (28)	12.2	(3.5),	9-17	13.5	(5.0),	5-20
Digit Symbol (133)	49.5	(19.9),	21-76	61.8	(10.7),	51-74
Letter Number Sequencing (21)	10.2	(4.36),	6-18	9.9	(1.4),	8-12
Block Design (68)	37.0	(14.3),	22-63	42.5	(12.8),	20-55
Matrix Reasoning (26)	12.0	(6.2),	4-19	16.7	(5.6),	7-23
Memory						

AMIPB Story Recall - immediate (56)	28.2	(10.7),	12-42	28.3	(9.9),	12-37
AMIPB - Story Recall - delayed (56)	23.0	(13.9),	4-40	23.9	(7.7),	10-32
AMIPB - Design Learning - immediate (45)	28.2	(8.6),	22-44	30.5	(7.6),	19-40
AMIPB - Design Learning - delayed (9)	5.2	(2.6),	3-9	6.4	(1.9),	3-9
AMIPB - Design Learning - B design (9)	3.0	(2.0),	1-6	4.5	(2.2),	1-8
Recognition Memory Test - Faces (50)	37.3	(6.4),	28-44	36.3	(4.3),	31-43
Doors & People Memory Test -						
Names Recognition (24)	16.8	(2.6),	15-22	17.7	(2.4),	14-21
Verbal skills						
Verbal Fluency – FAS	31.5	(10.9),	18-46	33.9	(3.7),	30-41
Verbal Fluency - Adjusted	36.5	(10.0),	27-51	38.3	(3.6),	33-45
Category Fluency - Animals	19.8	(4.3),	14-26	21.3	(3.2),	17-26
SCOLP - Sentence Comprehension (100)	50.5	(19.7),	23-77	47.5	(14.9),	30-71
Graded Naming Test (30)	13.8	(5.0),	8-20	16.5	(6.4),	9-24

Perception						
Rey Complex Figure Copy (36)	33.3	(1.6),	31-35	33.6	(2.8),	27-36
Executive function						
Modified Card Sorting Test - Categories (6)	4.5	(2.4),	1-6	5.5	(1.4),	2-6
Modified Card Sorting Test - Errors	13.3	(13.2),	3-32	6	(8.0),	2-25
Brixton Spatial Anticipation Test - Errors	22.5	(7.64),	10-29	14.9	(5.0),	10-25

Note: LTLE = Left temporal lobe epilepsy, RTLE = Right temporal lobe epilepsy.

Numbers in parentheses beside each test represent the highest possible raw score.

Table 4. Personal and Public memories from the Modified Crovitz scale for participants with epilepsy and controls

	Participants with TLE						Control participants		
M (SD), range	LTLE *N* = 7			RTLE *N* = 8			*N* = 8		
Mean number of personal memories recalled (12)	10.7	(1.4),	9-12	11.5	(0.5),	11-12	11.8	(0.5),	11-12
Mean number of public memories recalled (12)	8.4	(2.7),	5-12	10.9	(1.4),	8-12	11.4	(1.1),	9-12
Personal memories mean recall score (60)	42.1	(8.2),	32-58	48.9	(6.3),	40-59	53.8	(4.4),	47-60
Public memories mean recall score (60)	32.0	(11.0),	18-49	45.0	(5.9),	34-52	47.5	(4.3),	41-52

Note: LTLE = Left temporal lobe epilepsy, RTLE = Right temporal lobe epilepsy.

Numbers in parentheses beside each test represent the highest possible raw score.

Table 5. Memories recalled on the Abbreviated Singular Experiences Test for participants with epilepsy and controls

	Participants with epilepsy						Control participants		
M (SD), range	LTLE *N* = 6			RTLE *N* = 8			*N* = 8		
Number of experiences identified (40)	17.3	(5.5),	7-22	20.9	(3.8),	15-25	23.8	(3.5),	17-28
Number of specific occasions identified (40)	13.3	(4.6),	7-21	18.5	(3.6),	13-23	21.8	(4.4)	13-26
Proportion specific events (1.0)	0.8	(0.2),	0.6-1.0	0.9	(0.1),	0.8-1.0	0.9	(0.06),	0.8-1.0

Note: LTLE = Left temporal lobe epilepsy, RTLE = Right temporal lobe epilepsy.

Numbers in parentheses beside each test represent the highest possible raw score.

Table 6. Autobiographical memory scores for participants with early and late onset epilepsy

M (SD), range	Participants with epilepsy					
	Early onset <5 years			Late onset >18 years		
	N = 5			*N* = 5		
Autobiographical Memory Interview						
Childhood subtotal (9)	5.2	(0.8),	4-6	4.2	(1.9),	2-7
Early adult subtotal (9)	6.2	(1.1),	5-7	5.6	(0.6),	4-6
Recent life subtotal (9)	7.4	(1.1),	6-9	6.6	(0.6),	6-7
Modified Crovitz test						
Personal memories recall score (60)	42.0	(4.3),	37-47	48.8	(7.9),	40-59
Public memories recall score (60)	30.8	(9.8),	18-44	44.2	(9.6),	28-52
Abbreviated Singular Experiences test						
Proportion specific events (1.0)	0.7	(0.1),	0.6-0.8	0.9	(0.1),	0.7-1.0

Note. Numbers in parentheses beside each test represent the highest possible raw score.

Table 7. Correlation matrix for autobiographical memory tests and neuropsychological test scaled scores for participants with left temporal lobe epilepsy

	Autobiographical Memory Interview				Modified Crovitz		Abbreviated Singular Experiences Test
	Childhood	Early adult life	Recent life	Total	Personal	Public	Proportion specific events
NART FSIQ	-.556	.346	.080	-.021	.361	.155	-.684
WAIS III - Similarities	.265	.941**	.759	.802	.748	.673	.263
WAIS III - Information	.274	.945**	.697	.790	.502	.769	.209
AMIPB Story Recall - immediate	-.217	.673	.496	.398	.410	.453	-.547
AMIPB - Story Recall - delayed	-.574	.000	-.274	-.306	-.207	-.272	-.676
AMIPB - Design Learning - immediate	.154	.572	.340	.451	-.144	.585	-.202
AMIPB - Design Learning - delayed	.443	.847*	.683	.803	.378	.875*	.427

AMIPB - Design Learning - design B	-.600	.058	.215	-.276	-.041	-.282	-.637
Doors & People Memory Test - Names Recognition	-.097	.572	.222	.317	-.079	.458	-.252
Verbal Fluency	-.080	.036	-.033	-.023	-.102	-.195	-.431
Category Fluency	.372	.626	.533	.620	.185	.485	-.083
SCOLP Test - Sentence Comprehension	-.218	.487	.313	.251	.498	.085	-.317
Graded Naming Test	.221	.922**	.751	.772	.605	.692	.000
Brixton Spatial Anticipation Test	.135	.840*	.581	.648	.256	.810	-.005

Note: * $p < .05$; ** $p < .01$

Table 8. Correlation matrix for autobiographical memory tests and neuropsychological test scaled scores for participants with right temporal lobe epilepsy

	Autobiographical Memory Interview				Modified Crovitz		Abbreviated Singular Experiences Test
	Childhood	Early adult life	Recent life	Total	Personal	Public	Proportion specific events
NART FSIQ	-.589	.095	.279	.473	.469	.166	.550
WAIS III - Similarities	-.698	.907**	.576	-.848**	-.602	.403	-.006
WAIS III - Information	.543	.000	.124	.372	-.088	.375	.426
AMIPB Story Recall - immediate	.270	.095	.128	.231	-.504	-.388	-.288
AMIPB - Story Recall - delayed	.151	-.138	.144	.099	-.651	-.236	-.074
AMIPB - Design Learning - immediate	.151	.580	.507	.402	-.060	-.183	.456
AMIPB - Design Learning - delayed	.431	-.046	.391	.371	-.262	.319	-.139

AMIPB - Design Learning - design B	.168	.414	.661	.414	-.221	-.508	.316
Doors & People Memory Test - Names Recognition	.505	.091	.061	.354	.380	.421	.229
Verbal Fluency	.346	-.041	.418	.328	-.301	-.221	-.158
Category Fluency	-.600	-.731*	-.171	-.618	-.704	.105	-.029
SCOLP Test - Sentence Comprehension	-.698	-.907**	-.576	-.848	-.602	.403	-.006
Graded Naming Test	.284	-.208	-.025	.112	-.100	.695	.574
Brixton Spatial Anticipation Test	-.085	-.285	.012	-.126	-.262	.391	.462

Note: * $p < .05$; ** $p < .01$

Figure 1. Autobiographical Memory Interview subtotal mean scores

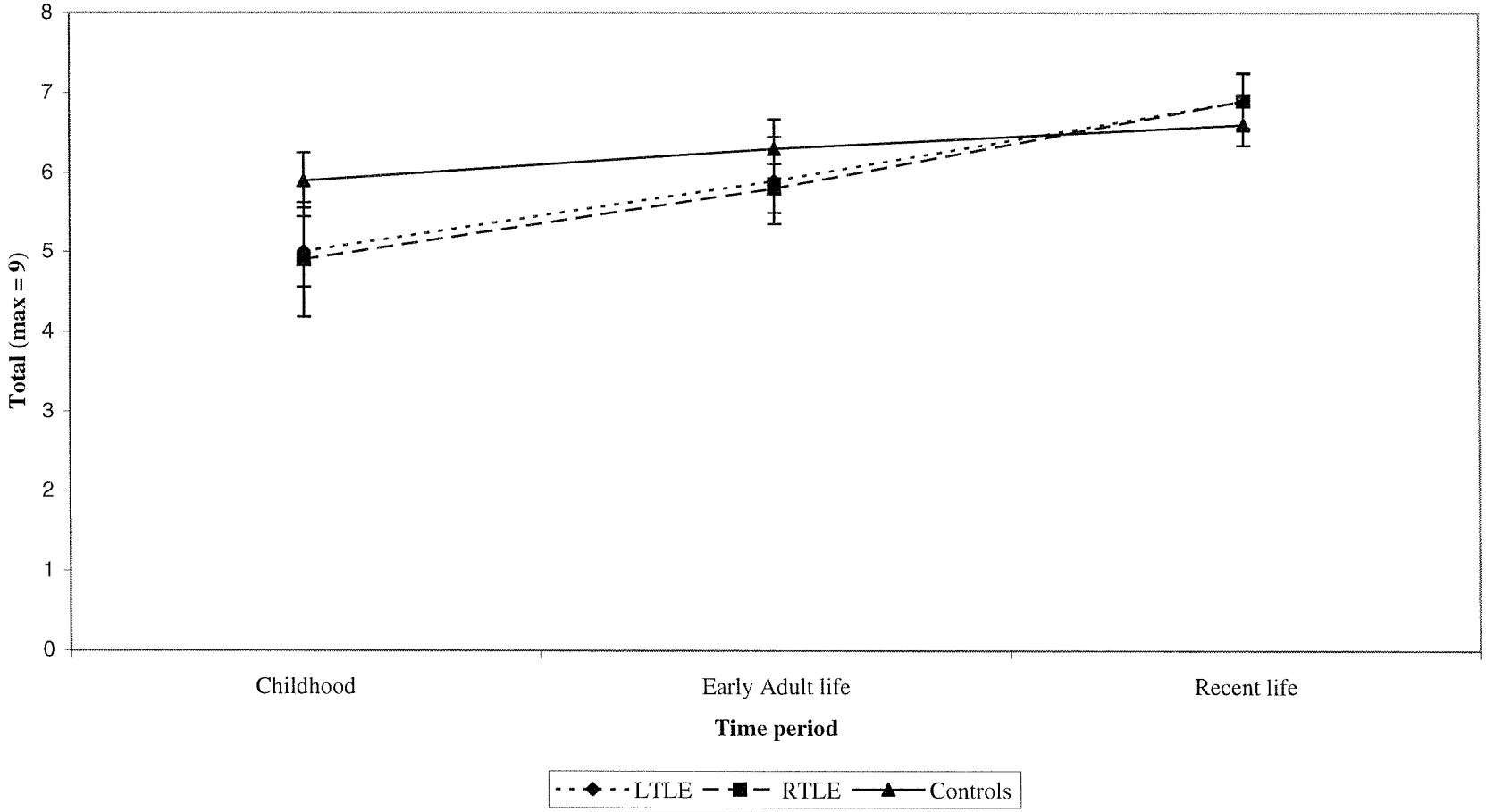


Figure 2. Mean recall of Personal memories on the Modified Crovitz from different time periods

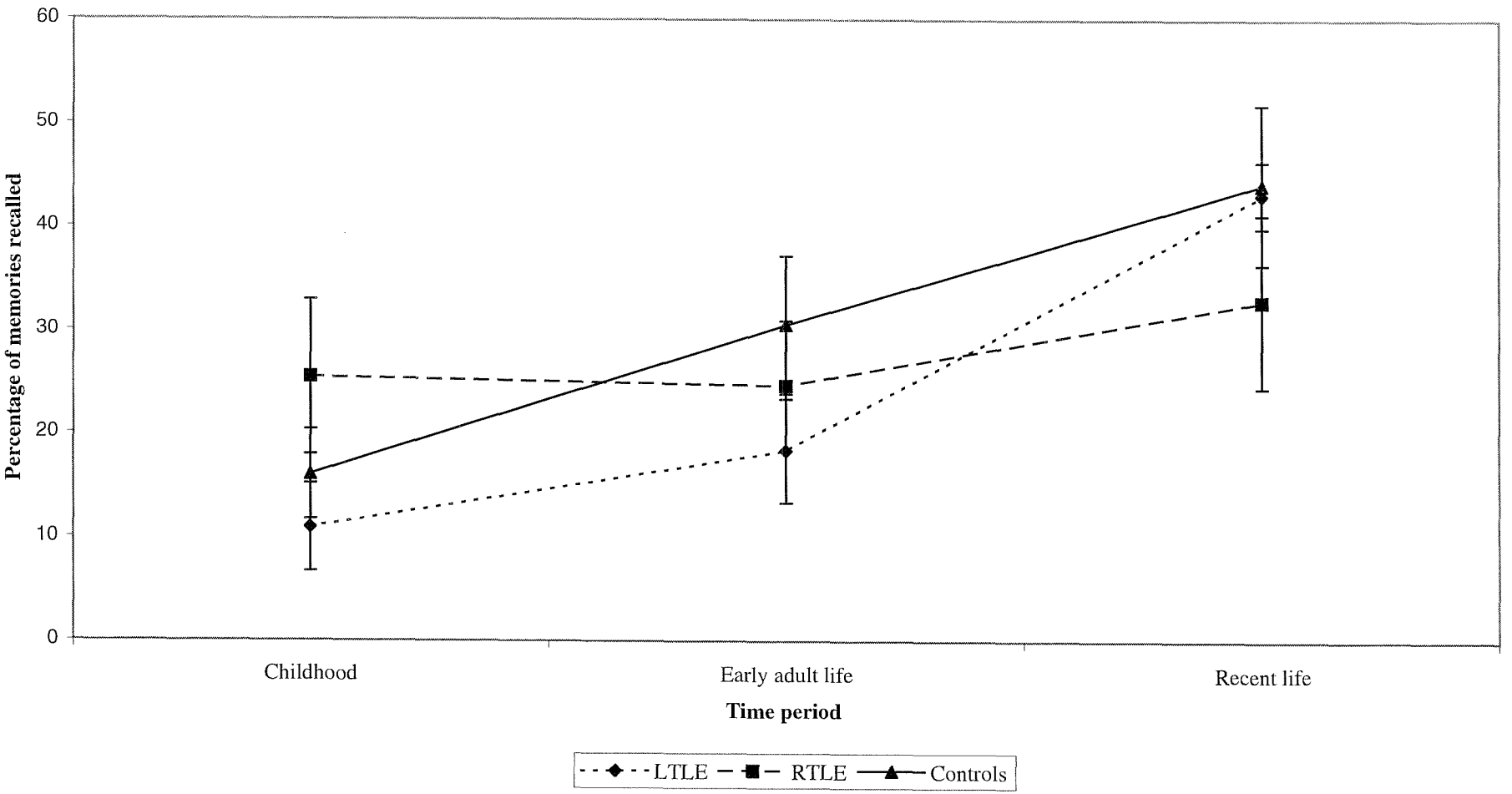


Figure 3. Mean recall of Public memories on the Modified Crovitz test from different time periods

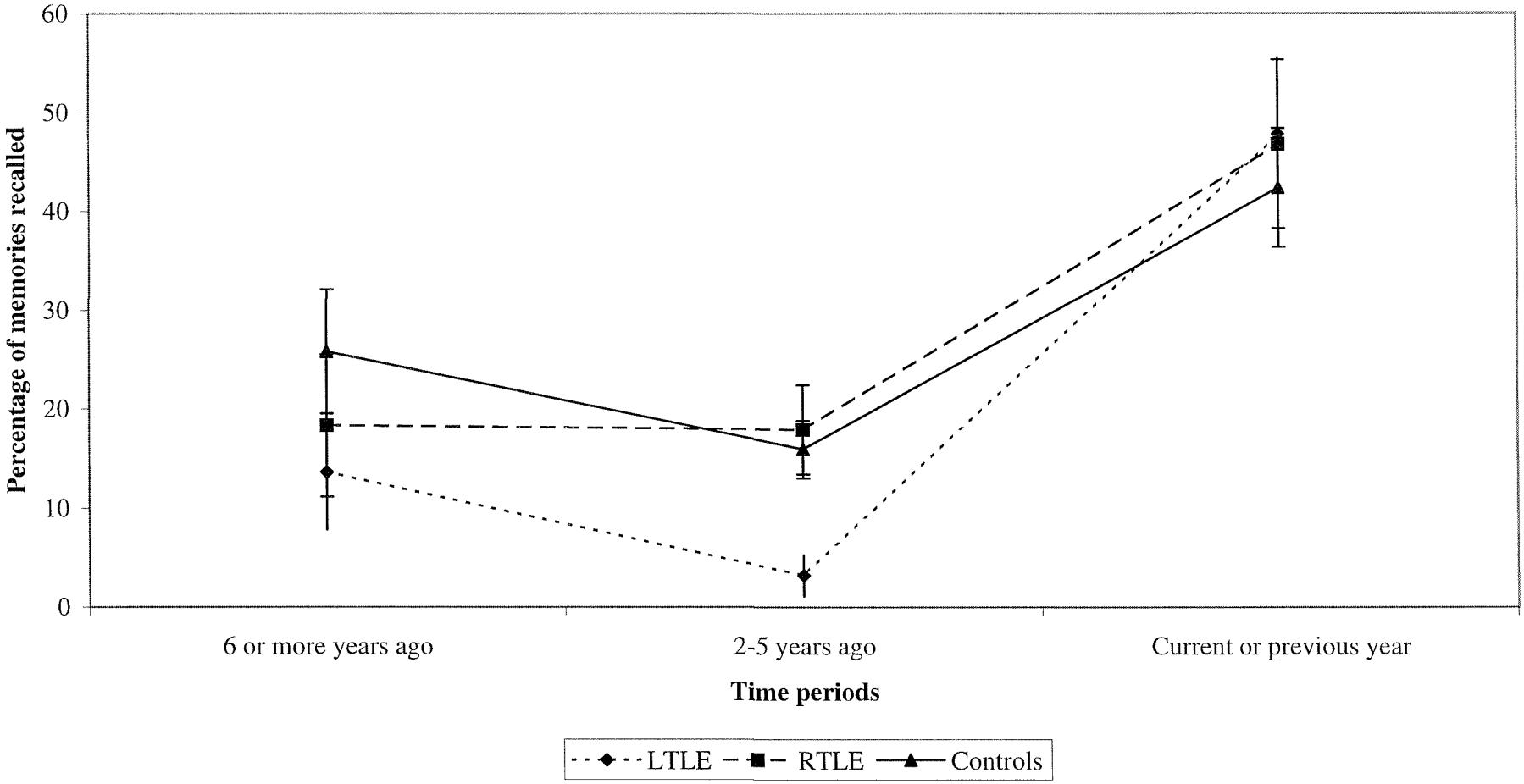


Figure 4. Abbreviated Singular Experiences Test mean memory and imagery ratings

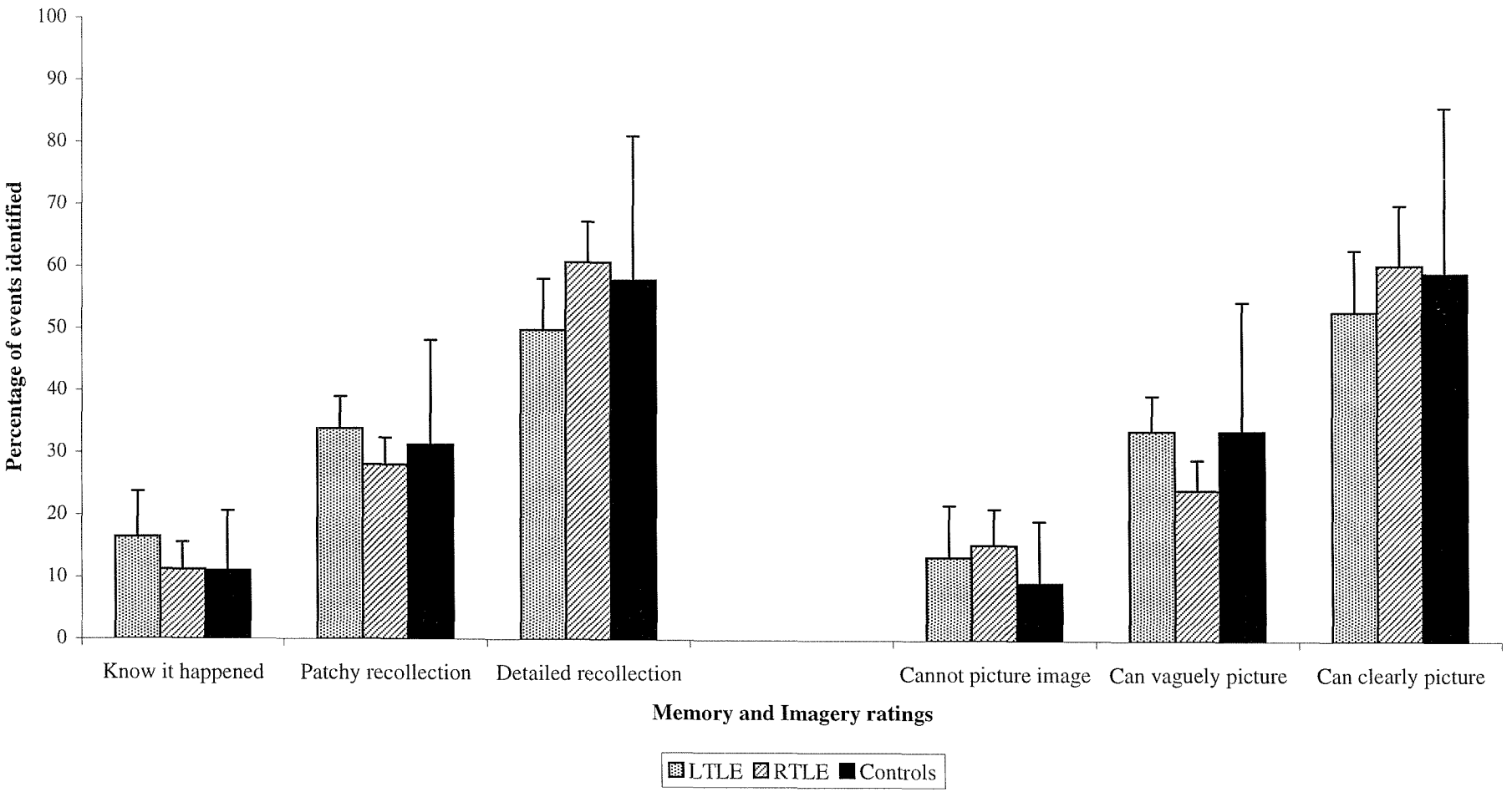
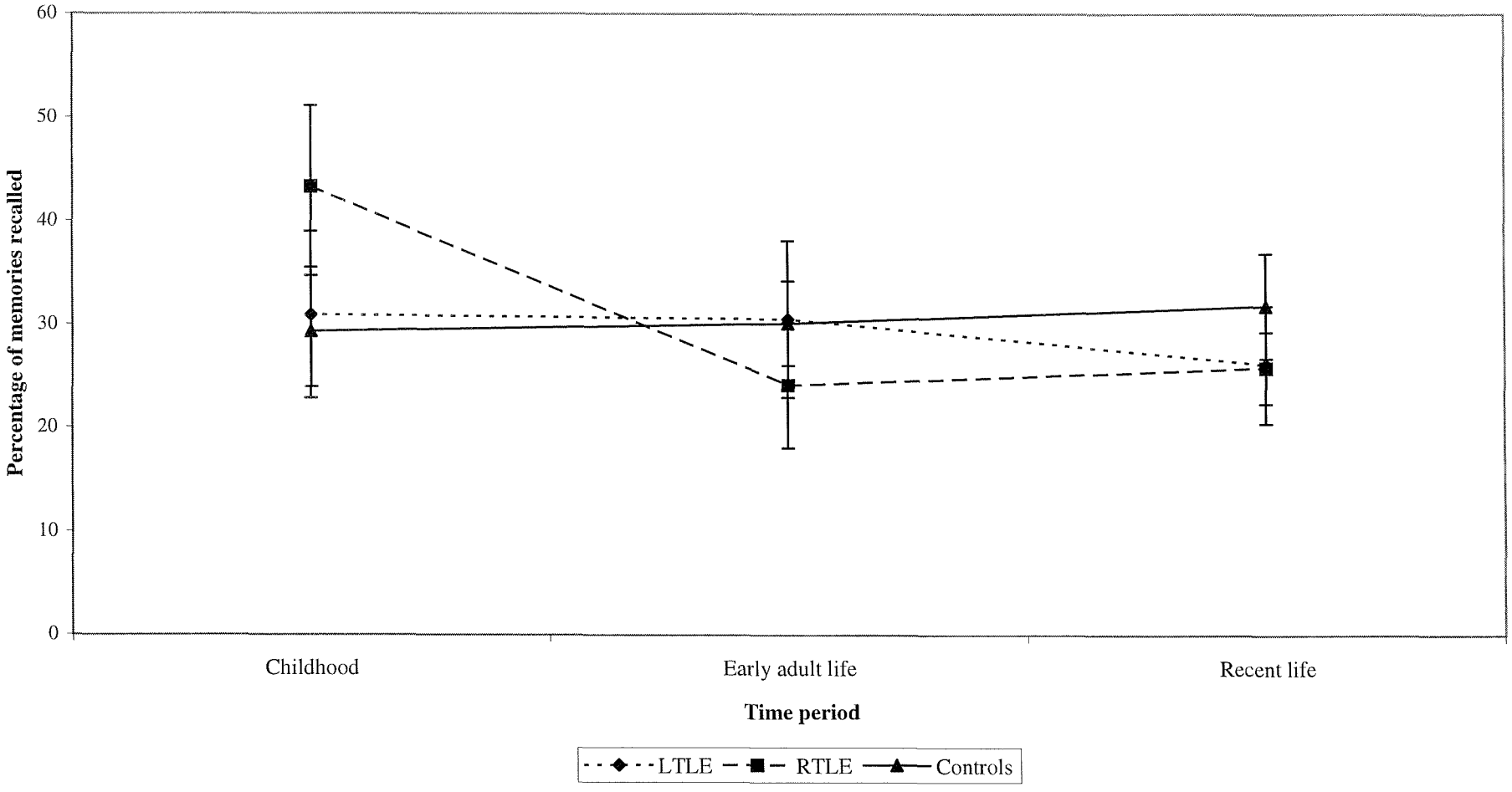


Figure 5. Mean recall of memories from different time periods on the Abbreviated Singular Experiences Test



Appendices

Appendix I

Instructions for authors submitting to Brain

Instructions to authors

ONLINE SUBMISSIONS. You are encouraged to submit your manuscript online. Once you have prepared your manuscript according to the instructions below please visit http://brain.manuscriptcentral.com to submit online.

Brain publishes definitive papers on neurology and related clinical disciplines, and on basic neuroscience, including molecular and cellular biology, and neuropsychology when they have a neurological orientation and are clearly relevant to the understanding of human disease. In the field of neuropsychology, *Brain* is particularly interested in investigations which bring together brain structure and function, or which make theoretical contributions to the understanding of cerebral mechanisms. Papers which are predominantly technical or methodological in nature or which present hypotheses or models unsupported by original data, are not suitable.

Brain does not publish preliminary reports of work in progress or brief reports of single cases. More detailed studies of single cases will be considered only when they definitively resolve an important problem in the field or when the data lead to a significant conceptual advance. Studies of single cases which can be readily performed on groups of patients will not be accepted.

Review articles if authoritative and topical will be considered.

Address all correspondence to Professor J. Newsom-Davis, Editor of Brain, Institute of Neurology, Queen Square, London WC1N 3BG, UK (Tel: 0207 405 4616; Fax: 0207 405 4617; E-mail: brain@ion.ucl.ac.uk). All submissions will be acknowledged on arrival at the *Brain* editorial office.

PAPERS must be typewritten in the style of *Brain* on one side of the paper only. They should be *double-spaced*, including text, tables, legends and references. In addition to the full title of the paper, which should not exceed 100 characters including spaces, authors should supply a running title which will appear at the heads of the pages. This should not exceed 40 characters, including spaces. A short summary, not exceeding 400 words, followed by appropriate keywords up to a maximum of five, to appear at the beginning of the paper, should also be provided. The total number of words in the text (excluding references, tables and figure legends) should also be indicated. *Brain* does not set an upper limit to the number of words, but also does not encourage prolixity. Authors need to know that space in the journal is strictly limited, and that they will be asked to shorten a manuscript that is judged to be disproportionately long. The full address, telephone and fax number of the corresponding author should appear on the title-page.

Papers in which experiments on patients or healthy volunteers are reported must record the fact that the subjects' consent was obtained according to the declaration of Helsinki (BMJ 1991; 302: 1194) and that the Ethical Committee of the Institution in which the work was performed has approved it. Consent must be also recorded when photographs of patients are shown or other details are given which could lead to the identification of the individuals.

Experiments with animals should be performed in accordance with the legal requirements of the relevant local or national authority, and the name of the authorizing body should be stated in the paper. Procedures should be such that experimental animals do not suffer unnecessarily. The text of the paper should include experimental details of the procedure and of anaesthetics used. The Editorial Board reserves the right to reject papers where the ethical aspects are, in the Board's opinion, open to doubt.

If online submission is not possible, please send a disk and four copies of the paper. These will not be returned if the paper is not accepted for publication. The illustrations will be returned if a request is made at the time of submission. Should the paper be accepted subject to revision, three copies of the revised version must be submitted (two to be highlighted in the places where changes have been made) together with a disk (preferably 3½ inch in PC Microsoft Word) labelled with: name of first author, manuscript number; software and hardware used; the name of the file(s) to be processed. If a paper is provisionally accepted subject to revision, it should be returned in its amended form within 6 months.

At the time of the initial submission, the paper must be accompanied by the following declaration: 'The work reported in the attached paper entitled . . . has not been and is not intended to be published anywhere except in *Brain*'. It must be signed by *all* authors. Previous publications of the results in abstract form will not preclude consideration. For online submissions this letter must be sent separately by post.

CONFLICT OF INTEREST. Potential financial interests must be disclosed to the Editor in the form of a statement in the covering letter. This statement will be published at the Editor's discretion. The conflict of interest test is simple: is there anything–e.g. shareholding in or receipt of a grant or consultancy fee from a pharmaceutical company or a contract from a medical devices manufacturer–that would embarrass you or any of your co-authors if it were to emerge after publication and you had not declared it? All sources of funding must be disclosed as an acknowledgement in the text.

BIBLIOGRAPHIC REFERENCES should be limited to essential literature. They should be listed at the end of the

paper in alphabetical order and not numbered. For multiple publications by the same author, those by the author alone are listed first, those with two authors listed after these and any with three or more authors must be given up to a maximum of six and any more should be indicated by *et al.* If there is more than one paper for a given year, these should be listed *a*, *b*, *c*, etc. The references should be presented in the Vancouver style (see Uniform requirements for manuscripts submitted to biomedical journals. *The Lancet*: http://www.thelancet.com/authorinfo or Ann Intern Med 1997; 126: 36–47) and journal titles given in their abbreviated forms (see *List of Journals Indexed in Index Medicus*).

Examples of reference style:

Barkovich AJ. Disorders of neuronal migration and organization. In: Kuzniecky RI, Jackson GD, editors. Magnetic resonance in epilepsy. New York: Raven Press; 1995. p. 235–55.

Bushby KMD, Gardner-Medwin D. The clinical, genetic and dystrophin characteristics of Becker muscular dystrophy. I. Natural history. J Neurol 1993; 240: 98–104.

Costa DC, Morgan GF, Lassen NA, editors. New trends in nuclear neurology and psychiatry. London: John Libbey; 1993.

Handwerker HO, Kobal G. Psychophysiology of experimentally induced pain. [Review]. Physiol Rev 1993; 73: 639–71.

In the text, numbered references are not used. The author's name and year of publication are given in brackets. If there are three or more authors, the name of the first is followed by *et al.* The punctuation in the text, should follow the style of the journal (see current issue). Papers in which the reference citations do not follow this format may be returned for retyping. References to papers 'in preparation' or 'submitted' are not acceptable; if 'in press' the name of the journal or book must be given. Reference citations should not include personal communications' or other inaccessible information; information derived from personal communications or from unpublished work by the authors should be referred to in the text.

ILLUSTRATIONS should be clearly lettered original line-drawings or glossy prints, with their number and the author's name on the back. The journal reserves the right to reduce the size of illustrative material. Half-tone photographs, particularly electron micrographs or CT or MRIs must be of good quality. All micrographs must carry a magnification bar (e.g. 1 μm). Colour illustrations are accepted, but the authors will be required to contribute to the cost of the reproduction. Authors may if they wish obtain an estimate of the cost from OUP before submitting the paper for review. Apply to Oxford University Press, Great Clarendon Street, Oxford OX2 6DP, UK. Illustrations for which colour is not essential can be reproduced as black and white images in the print journal and, additionally, in colour as online Supplementary data. This option is not subject to colour charges. Authors should indicate clearly that they would like to take up this option in the covering letter and on the reverse of the figures. The availability of additional colour images as Supplementary data should be mentioned where relevant in the main text of the manuscript. (Instructions on how to submit colour figures as Supplementary data are available at http://www3.oup.co.uk/brainj/instauth/auth1.html). The number of illustrations should be kept to a minimum. The desired position of figures and tables should be indicated in the typescript of the paper (e.g. Fig. 1 near here, in brackets). Legends for figures should be listed on a separate sheet. All tables must bear a title. Footnotes may be used in the tables but not in the text.

ABBREVIATIONS FOR SCIENTIFIC UNITS should conform to the Système Internationale (SI units). The statistical guidelines advocated by the International Committee of Medical Journal Editors (Ann Intern Med 1988; 108: 266–73) should be followed.

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BOOKS FOR REVIEW. Please send books for review to the Book Review Editor: Professor C. M. Wiles, Department of Neurology (C4), University of Wales College of Medicine, Cardiff CF4 4XW, UK.

Appendix II

Letter of Ethics Committee approval

University of Southampton

Department of Psychology

University of Southampton
Highfield
Southampton
SO17 1BJ
United Kingdom

Telephone +44 (0)23 8059 5000
Fax +44 (0)23 8059 4597
Email

10 September 2001

Gina Carter
Trainee Clinical Psychologist
University of Southampton
Highfield, Southampton
SO17 1BJ

Dear Gina,

Re: Submission No. PSY/09/01

Following the conditional approval and in response to your recent letter, I am pleased to confirm **full approval** having received the required amendments.

This committee is fully compliant with the International Committee on Harmonisation/Good Clinical Practice (ICH) Guidelines for the Conduct of Trials involving the participation of human subjects as they relate to the responsibilities, composition, function, operations and records of an Independent Ethics Committee/Independent Review Board. To this end it undertakes to adhere as far as is consistent with its Constitution, to the relevant clauses of the ICH Harmonised Tripartite Guideline for Good Clinical Practice, adopted by the Commission of the European Union on 17 January 1997.

Yours sincerely,

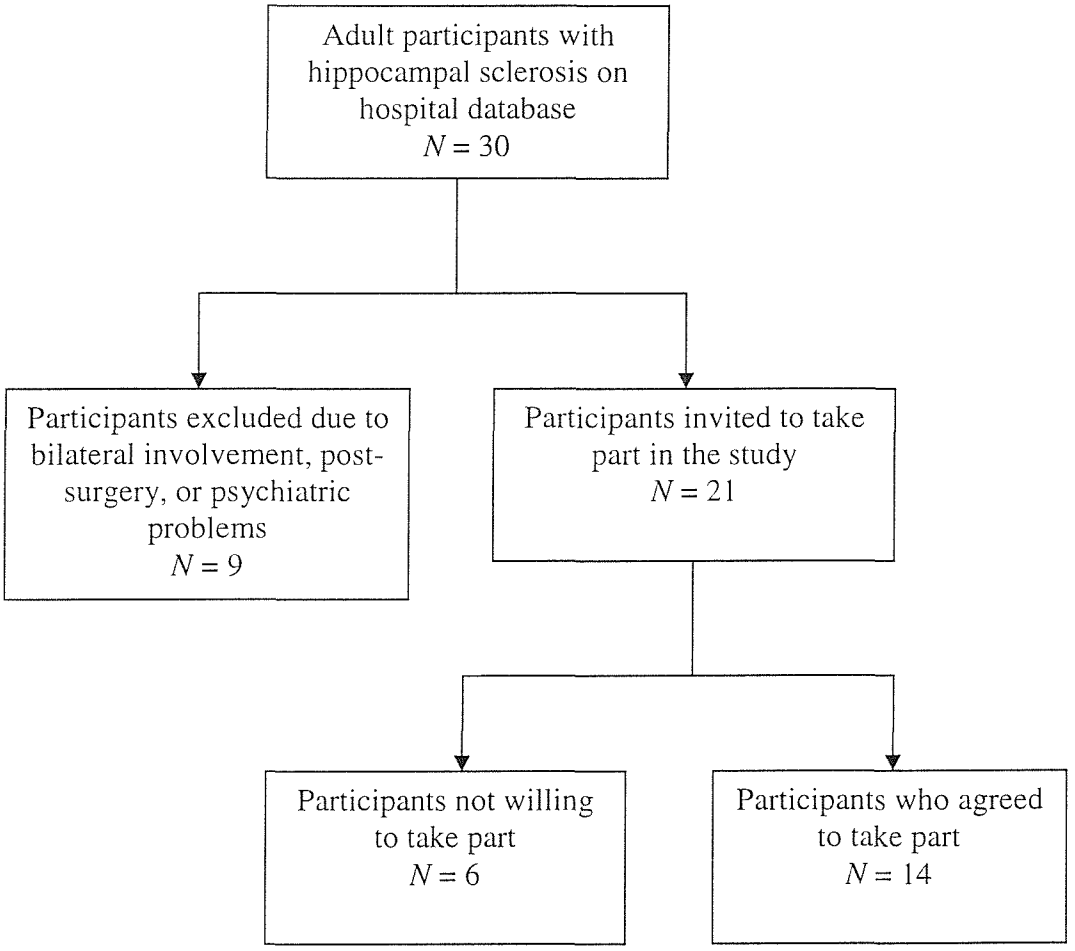
pp Professor Peter Coleman
Chairman
Psychology Sub-Committee, Southampton & S.W. Hants. Joint Ethics Committee

cc Janet Turner

Appendix III

Flow diagram of the recruitment process

FLOW DIAGRAM OF THE RECRUITMENT PROCESS



Appendix IV

Consent form

Note: In accordance with LREC guidelines the consent form was printed on headed paper.

ON HEADED PAPER

RESEARCH ON VERY LONG-TERM MEMORY IN EPILEPSY

CONSENT FORM FOR PARTICIPANTS

I, ...

have read the information sheet and hereby fully and freely consent to participate in the research study entitled: Very long-term memory functioning in people with temporal lobe epilepsy.

I understand that I may withdraw my consent and discontinue participation at any stage without affecting my future medical care. I understand that the data collected as part of this research project will be treated confidentially, and that published results of this research project will maintain my confidentiality.

I consent to the tape recording of the interview with me for the autobiographical memory test. I understand that the audiotape will be treated in strict confidence, that the contents will be used solely for the purposes of scoring the test and that the tape will be erased after use.

I confirm that the purpose of the study, and the nature and purpose of the procedures involved, have been explained to me by the researcher, that I have had an opportunity to discuss these matters with her.

Signed:..... *Date:*.....

Name:.....

I understand that if I have any questions about my rights as a participant in this research, or if I feel that I have been placed in any risk, I can contact the Chair of the Ethics Committee, Department of Psychology, University of Southampton, Southampton, SO17 1BJ. Phone: (023) 8059 3995.

Appendix V

Participant information sheet for people with temporal lobe epilepsy

Note: In accordance with LREC guidelines the information sheet was printed on headed paper.

ON HEADED PAPER

RESEARCH ON VERY LONG-TERM MEMORY IN EPILEPSY

INFORMATION SHEET FOR STUDY PARTICIPANTS

We would like to invite you to consider taking part in our study of very long-term memory, which is being carried out by a Trainee Clinical Psychologist at the University of Southampton in conjunction with Southampton Hospitals NHS Trust.

About the study

The study is investigating very long-term memory in people with epilepsy. The aim of the study is to gather more information about the level of very long-term memory problems experienced. This will help us develop better assessment procedures.

What your participation will involve

As part of the study you may be asked to complete some neuropsychological assessments. These ask you to do things such as copying a drawing and remembering it later, naming pictures, and reading words aloud. You will also be asked to complete three memory tasks which involve describing some events from your past. The study will involve one or two sessions, each lasting approximately one to two hours. The sessions can be carried out at your home or at Southampton General Hospital, depending on your preference. All your travelling expenses for taking part in the study will be met.

This kind of study is not considered to involve any risk to participants. However, if you are concerned about any aspect of the study you should not hesitate to speak to the researchers. Your participation is voluntary and you may withdraw from the study at any time. If you decide not to participate, or to withdraw at a later stage, this will not affect your normal care and treatment at the hospital in any way.

Confidentiality

Personal information acquired during the study will not be released to or viewed by anyone other than the researchers involved in this study. Results of this study will not include your name or any other identifying characteristics.

If you would like more information or if you have any questions, please do not hesitate to contact us.

Gina Carter
Trainee Clinical Psychologist

Prof. N. Kapur
Consultant Neuropsychologist

THANK YOU FOR YOUR INTEREST IN OUR RESEARCH

Appendix VI

Participant information sheet for controls

Note: In accordance with LREC guidelines the information sheet was printed on headed paper.

ON HEADED PAPER

RESEARCH ON VERY LONG-TERM MEMORY IN EPILEPSY

INFORMATION SHEET FOR STUDY PARTICIPANTS

We would like to invite you to consider taking part in our study of very long-term memory, which is being carried out by a Trainee Clinical Psychologist at the University of Southampton in conjunction with Southampton Hospitals NHS Trust.

About the study

The study is investigating very long-term memory in people with epilepsy. The aim of the study is to gather more information about the level of very long-term memory problems experienced. This will help us develop better assessment procedures. In order to do this we also need to compare the performance of people with epilepsy against the performance of people who we know do not have epilepsy.

What your participation will involve

As part of the study you will be asked to complete three memory tasks which involve describing some events from your past. The study will involve one session lasting two hours carried out at Southampton General Hospital. All your travelling expenses for taking part in the study will be met.

This kind of study is not considered to involve any risk to participants. However, if you are concerned about any aspect of the study you should not hesitate to speak to the researchers. Your participation is voluntary and you may withdraw from the study at any time. If you decide not to participate, or to withdraw at a later stage, this will not affect your normal care and treatment at the hospital in any way.

Confidentiality

Personal information acquired during the study will not be released to or viewed by anyone other than the researchers involved in this study. Results of this study will not include your name or any other identifying characteristics.

If you would like more information or if you have any questions, please do not hesitate to contact us on **023 8079 6577**.

Gina Carter
Trainee Clinical Psychologist

Prof. N. Kapur
Consultant Neuropsychologist

THANK YOU FOR YOUR INTEREST IN OUR RESEARCH

Appendix VII

Testing protocol

TESTING PROTOCOL

INTRODUCTION

Thank you very much for agreeing to help me with my research. My name is Gina Carter and I'm a Trainee Clinical Psychologist at Southampton University. I am conducting some research looking at long-term memory in people with epilepsy with Professor Kapur at the Wessex Neurological Centre. I will need about two hours of your time today. If at any stage, however, you want to stop before the end please just let me know. You are not obliged to continue if you do not wish to.

Before we start there are two other things I need to tell you:

Firstly, I will not be able to discuss the results of the questions with you today because I will need time to score them afterwards. And secondly, any information you give me is confidential. No individual's results will be identifiable.

OUTLINE OF THE TESTING

I'm going to ask you to complete three tasks today. These look at your memories for past events. Don't worry if you think your memory for an event is not perfect or if you can't think of an answer. We do not expect you to be able to remember every event about which we ask you. Just tell me as much as you can remember, in as much detail as possible. There are no right or wrong answers to these tasks. We are interested in your recall. However, please don't guess. Just do the best you can okay?

CONSENT

If you don't mind I would like to tape record your answers today just to make sure I don't miss anything. The tape will be wiped once I have finished scoring your responses. Is that okay with you?

Do you have any questions about taking part in the research?

If you feel happy to carry on, the first thing I will ask you to do is to sign a consent form. This is to say that you are happy to take part in my research, that you don't mind being tape recorded, and that I have explained everything to you.

INFORMATION

Before we start the memory tests I'd like to get a few details from you.

Complete information obtained on the information sheet in the test pack.

Can you tell me your:
Date of birth
Age
Do you work? If so, what do you do?
How old you were when you left school?

For the participants with epilepsy also obtain the following information about their epilepsy and record it on the information sheet.

I would also like to find out a little bit about your epilepsy. Can you tell me:
How old you were when your epilepsy started?
How frequently, approximately, would you say you have seizures?
What would be the average frequency of your seizures over the last six months?
What form do the seizures take?
What anti-epileptic medication are you currently taking?

TEST 1 AUTOBIOGRAPHICAL MEMORY TEST

The first task asks about your memory for incidents which have occurred at different stages of your life. I will ask you for a memory from your school days, early adult life and from more recent times.

Here's the first one...

- Administer the 'Autobiographical Incidents Schedule' from the AMI

If the participant fails to give a response the suggested prompts outlined in the AMI test sheet should be given. Encouragement can also be given for participants to elaborate on any information they have provided in their response:

Can you tell me more about this?
That's great, tell me more?

For question A7 (Present hospital or institution) the question is rephrased to:

Can you recall an incident that has occurred recently involving a doctor, a nurse or other health or social worker?

When the AMI questions have been finished:

Thank you for completing the first task. Before we move on do you have any comments?

Ok, let's move on to the second task now.

TEST 2 MODIFIED CROVITZ TEST

The next task is similar to the one before but this time I will give you a word and I will then ask you to remember events that the word makes you think of. Some of the events I will ask you to think of will be personal events that have happened to you and some will be news events. As I said earlier, don't worry if you can't always remember an event, we don't expect you to be able to answer every question. Just do your best.

For the first set of words I would like you to tell me about events that have happened to you personally.

I will say a word to you and then I'd like you to recall an event that you yourself experienced that could be associated with the word. Try to choose an event that you yourself have experienced and that you can remember as having happened at a particular time and in a particular place.

For example, if the word was bottle you might recall a time at a Christmas party when you or someone else dropped a bottle and it broke leaving stains on the carpet.

- Administer Personal Memories

Encourage the participants to describe a particular event, particular time and particular place in as much detail as they can by offering the following prompts and questions:

Can you tell me more about this?
Where was it?
What time?
Who was there?
How long did it last/ take?
How old were you?

Once the personal memories recall has been completed:

Well done. We're half way through this test now. This time I will say a word to you and I'd like you to try to recall a news event that was famous and that could be associated with the word. You can choose any news event that has happened but try to choose one that you can remember as having happened at a particular time and in a particular place.

For example, if the word was boxer you might remember a news event where a boxer was knocked down during a fight and later died from his injuries.

- Administer the Public Memories

Encourage the participants to describe a particular event, particular time and particular place in as much detail as they can by offering the following prompts and questions:

Can you tell me more about this?
Where was it?
What time?
Who was there?
How long did it last/ take?
How old were you?

On completion of the public memories recall test:

Thank you very much for completing that task. That one can be quite difficult, I found it hard myself when I first did it.

TEST 3 LETTER-NUMBER SEQUENCING (Only for the people with epilepsy)

We've got one more memory task to do. But before we do, to give you a bit of a change I'd like to spend 5 minutes on a concentration task.

In this task I am going to say a group of numbers and letters. After I say them, I want you to tell me the numbers first, in order, starting with the lowest number. Then tell me the letters in alphabetic order. For example, if I say B - 7, your answer should be 7 - B. The number goes first, then the letter. If I say 9 - C - 3, then your answer should be 3 - 9 - C, the numbers in order first, then the letters in alphabetic order. Let's practice.

6 - F
G - 4
3 - W - 5
T - 7 - L
1 - J - A

Okay? If you have got the hang of it lets begin the items. Remember, numbers then letters, numbers, letters okay?

- Administer Letter - Number Sequencing items

Once the task is completed:

Thank you for completing that task. It gets quite tricky towards the end doesn't it?

If it's okay with you now I'd like to move on to the last memory task.

TEST 4 ABBREVIATED SINGULAR EXPERIENCES TEST

In this task I'm going to read you a list of experiences. I want you to tell me which of them you have experienced. If you've experienced some of them

more than once I would like you to think about your clearest memory for the event. Each time I will then ask you for some details about how well you can remember the event. Remember, don't worry if you think you can't remember some. Also, don't take too long thinking about each one and please don't guess.

- Administer the Abbreviated Singular Experiences Test

Q1. Have you ever... (yes/ no/ unsure)
If answered no / unsure - move on to the next item
If answered yes - ask Q2.

Q2. Have you had this experience once or more than once?
Record response and ask Q3.

Q3. Can you single out a specific occasion when this event happened?
If answered no - move on to the next item
If answered yes - ask Q4.

Q4. Ok, now I want you to rate how well you can remember the experience. Remember, I want you to think about one particular occasion. How would you rate your memory for the experience? If you know the event happened but cannot recall any details then rate it as 'know it happened'. If you feel you can recall a few details, but your memory for the event is rather patchy then rate it as 'patchy'. Or, if you have a detailed memory for the event and can remember details about when and where it happened, if anyone else was there, and how you felt at the time then rate your memory as 'detailed'.

Show card. Record rating, move on to Q5.

Q5. Now I'd like you to rate your ability to picture the experience. If you know the event happened but cannot picture it in your mind's eye the rate it as 'cannot picture'. If you can vaguely picture the event in your mind's eye then rate it as 'vague'. If you can clearly picture and can relive it in your imagination as if it were happening now then please rate it as 'clear'.

Show card. Record rating, move on to Q6.

Q6. Finally, can you tell me approximately when this took place or roughly how old you were at the time?

Record response.

Complete questions for remaining items.

Once the Abbreviated Singular Experiences Test has been completed:

> *Thank you very much for completing that task. Well done, that is the end of my questions. Thank you very much for giving me your time to help with this work. Have you got any questions or comments about the tasks we've done today?*
>
> *What will happen to your answers now is I will go away and score them and then compare them to the other people I have been testing. Once I have finished seeing everybody I will analyse the results and will then be able to send you a short summary of the results of the research if you are interested. Would you like a brief summary of the research? If so, where should I send it?*

Appendix VIII

Modified Crovitz Test

MODIFIED CROVITZ TEST

A. Personal Memories

I will say a word to you and then I'd like you to recall an event that you yourself experienced that could be associated with the word. Try to choose an event that you yourself have experienced and that you can remember as having happened at a particular time and in a particular place.

For example, if the word was **bottle** *you might recall a time at a Christmas party when you or someone else dropped a* bottle *and it broke leaving stains on the carpet.*

Can you tell me about an event that your yourself have experienced associated with the word ..... that you can recall as having happened at a particular time and in a particular place. Try to give me as much details as you can.

1. PLANE

2. SHIP

3. CAR

4. TRAIN

5. FIRE

6. BIRTH

7. WEDDING

8. DEATH

9. SPORT

10. HOUSE

11. COURT

12. FOOD

MODIFIED CROVITZ TEST

B. Public Memories

I will say a word to you and then I'd like you to recall a news event that was famous and that could be associated with the word. You can choose any news event that has happened but try to choose one that you can remember as having happened at a particular time and in a particular place.

For example, if the word was **boxer** *you might remember a news event where a* boxer *was knocked down during a fight and later died from his injuries.*

Can you tell me about a news event that has occurred associated with the word ..... that you can recall as having happened at a particular time and in a particular place. Try to give me as much details as you can.

1. PLANE

2. SHIP

3. CAR

4. TRAIN

5. FIRE

6. BIRTH

7. WEDDING

8. DEATH

9. SPORT

10. HOUSE

11. COURT

12. FOOD

Appendix IX

Comparison of scoring systems for the Crovitz

COMPARISION OF SCORING SYSTEMS FOR THE CROVITZ

The conventional method of scoring responses on the Crovitz task follow the guidelines described by Crovitz and Schiffman (1974). Responses are scored on a 0-3 scale according to the level of detail given. The maximum score of 3 is given if time and place are specified along with details about the event. Two points are awarded if less detail is given or time and place are not specified. One point is given for a response which provides more general rather than specific information. Although this scoring method has been widely used, some criticisms have been made of it because of the variation of responses which would fall under a particular score (Nadel *et al*, 2000). As a result differences in the level of detail given in the performance of participants may be missed.

Recent accounts have highlighted the need for a more sensitive measure of scoring which allows for differences in responses to be more easily distinguished. The scoring system proposed by Graham and Hodges (1997) achieves this aim. Responses are scored for both detail and episodic specificity using a 0-5 point scale. For a full score of 5 to be given, a response must provide a detailed account of a specific/single event. If a specific/single event is given but with little detail, a score of 4 is awarded. Likewise, a score of 3 is given for a generic/multiple event which contains a lot of detail, while a score of 2 is given if the account contains little detail. A score of 1 is given for a semantic definition, and a 0 if there is no response, or it is not related.

The Crovitz and Schiffman (1974) 0-3 scale scores and the Graham and Hodges (1997) 0-5 scale scores were compared for the responses to the Personal and Public memories on the Modified Crovitz test to examine the scales abilities to identify differences in performance.

For the level of detail and richness of the memories recalled on the Personal memories section of the Modified Crovitz test, a significant difference in mean performance was found between the groups by both the 0-3 scale ($F(2, 20) = 6.8$, $p = .006$), and the 0-5 scale ($F(2, 20) = 6.2$, $p = .008$) (see Table below). The scores on the Public memories component also found a significant difference between groups on both the 0-3 scale ($F(2, 20) = 6.1$, $p = .009$), and on the 0-5 scoring system ($F(2, 20) = 9.3$, $p = .001$) (see table). However, a posthoc multiple comparisons analysis found the left TLE group to only differ significantly from the control group ($p = <.05$) only on the 0-3 scale, whereas the left TLE group differed significantly from both groups on the 0-5 scoring scale ($p = <.05$).

The inter-rater reliability of these two scoring systems was also investigated. Using the 0-3 scale the Spearman's Rho correlation coefficients were .66 ($p <.01$) for the personal memories component, and .73 ($p <.01$) for the public memories. The coefficients achieved for the 0-5 scale were higher with a coefficient of .83 ($p <.01$) for personal memories and .79 ($p <.01$) for public memories.

Whilst both scales were demonstrated to distinguish differences in performance between the groups, the 0-5 scale did prove to be more sensitive at demonstrating differences in performance on the Public memories. This finding, in combination

with the higher inter-rater reliability found for the 0-5 scale, led to the decision to adopt this scoring system when analysing performance on the Modified Crovitz task.

Table. Scores for the Modified Crovitz test Personal and Public memories using the two scoring systems

	Participants with TLE						Control participants		
M (SD), range	LTLE $N = 7$			RTLE $N = 8$			$N = 8$		
Crovitz and Schiffman (1974)									
0-3 scale scoring system									
Personal memories (36)	27.1	(4.7),	20-36	29.4	(2.7),	26-33	33.3	(2.4),	30-36
Public memories (36)	20.1	(9.1),	10-34	28.3	(4.8),	19-36	30.8	3.4	24-33
Graham and Hodges (1997)									
0-5 scale scoring system									
Personal memories (60)	42.1	(8.2),	32-58	48.9	(6.3),	40-59	53.8	(4.4),	47-60
Public memories (60)	32.0	(11.0),	18-49	45.0	(5.9),	34-52	47.5	(4.3),	41-52

Note: LTLE = Left temporal lobe epilepsy, RTLE = Right temporal lobe epilepsy.

Numbers in parentheses beside each test represent the highest possible raw score.

Appendix X

Abbreviated Singular Experiences Test

ABBREVIATED SINGULAR EXPERIENCES TEST

ITEM	Q1. Have you ever… YES/ NO/ UNSURE (If no/ unsure – move on to next item) Q2. If yes – Have you had this experience once or more than once? ONCE/ MORE THAN ONCE	Q3. Single Occasion Can you single out a specific occasion when this event happened? YES/ NO (If no – move on to the next item)	Q4. Details Please rate your memory for the experience KNOW/ PATCHY/ DETAILED	Q5. Imagery Please rate your ability to picture the experience NO/ VAGUE/ CLEAR	Q6. Year/ age Can you tell me approximately when this took place or roughly how old you were at the time?
1. Been in a helicopter					
2. Ridden on a motorbike as a passenger or driver					
3. Driven a lorry					
4. Taken a driving test					
5. Broken down on the motorway					
6. Been in a police car					
7. Seen a sports personality in real life					
8. Had a car accident as a passenger					
9. Been in an ambulance					
10. Been bitten by a dog					
11. Had food poisoning					
12. Had a tooth out at the dentist					
13. Been to the Tower of					

London					
14. Had to break in to my own home					
15. Been to an anniversary celebration					
16. Had burst water pipes in my home					
17. Had to call out the fire brigade					
18. Been to a football match					
19. Seen a member of the royal family in real life					
20. Been to a tennis match					
21. Been to a circus					
22. Been horse-riding					
23. Been to a theme park					
24. Been to an aquarium or sea-life centre					
25. Stayed in a caravan					
26. Entered a competition					
27. Been stung by a wasp or bee					
28. Watched a radio or television programme being recorded in a studio					
29. Written to a member of parliament					
30. Seen a pop star in real life					
31. Had to go to a casualty dept					

32. Attended a job interview					
33. Been introduced to someone famous					
34. Been to a chiropractor					
35. Helped to change a flat tyre					
36. Lost something valuable					
37. Had my home burgled					
38. Been to Windsor Castle					
39. Been to the Harrods store					
40. Been to Madame Tussauds					

Appendix XI

Modification of the Singular Experiences Test

MODIFICATION OF THE SINGULAR EXPERIENCES TEST

Piloting the original format of the test

The draft version of the Singular Experiences Test (Kapur, 2001; Appendix XI) was piloted on 3 healthy control participants (mean age 28, SD 4.2, range 25-33). Participants were asked to indicate which of a list of possible experiences read out by the tester they had experienced. For each event to which they indicated that they had experienced they were asked three further questions. These were; i) whether they had experienced the event once or more than once; ii) how they would rate their memory for the event, either 'clear memory', 'patchy memory' or a 'familiar memory but with no recollection of detail'; and iii) to give an estimation of either, approximately when the event took place, or roughly how old they were at the time. For events on the list that that they had experienced more than once they were asked to give a rating and date for their clearest memory.

From reviewing the findings from the pilot data it was apparent that the test was time-consuming (taking between 36 and 43 minutes to complete) and feedback from the participants indicated that they had found it "tedious" as a result of it's length. To overcome these difficulties it was decided to modify the test for use in the present study to make it more acceptable for use with a clinical population, and to reduce the time taken when combined with the other autobiographical memory tests.

Selection of the items for the abbreviated version

In order to select the items for inclusion in the shortened form, 25 healthy control participants (mean age 37, SD 13.7, range 19-70) were asked which of the events listed in the Singular Experiences Test they had experienced. The distribution of the

items to which they responded positively was plotted. On the basis of the frequency of positive responses and comments made by the participants, a number of test items were excluded. These were items which had either a very low frequency of positive responses (i.e. 0-2 people responded), or had a very high frequency (i.e. 23-25 people responded). Highly prototypical items, i.e. those that were not easily dissociable or for which recall appeared to be more semantic than episodic in nature were also excluded. For example, when asked whether they had ever fallen off a bicycle many responded in a similar vein to one participant who explained "I know I must have fallen of a bicycle but I don't remember one time".

From the original 105 items included in the test 25 items were excluded. The test was then divided into two forms each consisting of 40 items. These two abbreviated forms were matched for item frequency (Form A; *M* 15.2; SD 5.72; Form B; *M* 15.2; SD 5.65) and may have potential for repeated testing if the two forms were validated. For the purposes of this study, Form A was administered throughout.

Appendix XII

Abbreviated Singular Experiences Test - Amount of detail rating scale

I WOULD RATE MY MEMORY FOR THE EVENT AS:

- KNOW IT HAPPENED -
I KNOW THE EVENT HAPPENED, BUT I CANNOT RECOLLECT ANY DETAILS

- PATCHY -
I CAN RECOLLECT A FEW DETAILS, BUT MY MEMORY FOR THE EVENT IS RATHER PATCHY

- DETAILED -
I HAVE A DETAILED MEMORY FOR THE EVENT - WHEN & WHERE IT HAPPENED, IF ANYONE ELSE WAS THERE, & HOW I FELT AT THE TIME

Appendix XIII

Abbreviated Singular Experiences Test - Level of imagery rating scale

I WOULD RATE MY ABILITY TO PICTURE THE EVENT AS:

- CANNOT PICTURE -
I KNOW THE EVENT HAPPENED, BUT I CANNOT PICTURE IT IN MY MIND'S EYE

- VAGUE -
I CAN VAGUELY PICTURE THE EVENT IN MY MIND'S EYE

- CLEAR -
I CAN CLEARLY PICTURE THE EVENT & RELIVE IT IN MY IMAGINATION AS IF IT WERE HAPPENING NOW

Appendix XIV

Exploration of the distribution of the data

EXPLORATION OF THE DISTRIBUTION OF THE DATA

One-Sample Kolmogorov-Smirnov tests revealed that a number of the measures were not normally distributed (Modified Card Sorting Categories, z = 1.785, p = .003; number of Modified Crovitz test personal memories, z = 1.547, p = .017; and proportion of memories on the Abbreviated Singular Experiences test for which no dates were given, z = 2.378, p = .000).

All the other measures were normally distributed (AMI childhood total, z = 0.857, p = .454; AMI early adult life, z = 0.863, p = .446; AMI recent life, z = 1.228, p =.098, Modified Crovitz test personal memories 0-3 scale, z = 0.616, p = .842; Modified Crovitz test personal memories 0-5 scale, z = 0.534, p =.938; proportion of Modified Crovitz test personal memories in the childhood time band, z = 0.734, p = .654; proportion of Modified Crovitz test personal memories in the early adult life time band, z = 1.030, p = .240, proportion of Modified Crovitz test personal memories in the recent life time band, z = 0.505, p = .960; Modified Crovitz test public memories 0-3 scale, z = 0.913, p = .376; Modified Crovitz test public memories 0-5 scale, z = 0.942, p = .338; proportion of Modified Crovitz test public memories from current and previous year time band, z = 0.734, p = .655; proportion of Modified Crovitz test public memories in from 2-5 years time band, z = 0.850, p = .466, proportion of Modified Crovitz test personal memories in from 6 or more years ago time band, z = 0.815, p = .520; number of Singular Experiences identified, z = 0.755, p = .619; number of specific occasions for the Singular Experiences identified, z = 0.615, p = .844; proportion specific events, z = 0.792, p = .557; proportion of Singular Experiences responses in the childhood time band, z = 0.738, p = .647;

proportion of Singular Experiences responses in the early adult life time band, z = 0.531, p = .941, proportion of Singular Experiences in the recent life time band, z = 0.471, p = .980).

The analysis of the inter-rater reliability data also revealed this to be not normally distributed (Rater 1 AMI scores, z = 1.965, p = .001; Rater 2 AMI scores, z = 1.852, p = .002; Rater 1 AMI scores, z = 1.965, p = .001; Rater 1 Modified Crovitz test personal memories scores, z = 2.287, p = .000; Rater 2 Modified Crovitz test personal memories scores, z = 2.209, p = .000; Rater 1 Modified Crovitz test public memories scores, z = 3.198, p = .000; Rater 2 Modified Crovitz test public memories scores, z = 3.076, p = .000;).

Appendix XV

Inter-rater Crosstabulation tables for the AMI and Modified Crovitz

INTER-RATER CROSSTABULATION TABLES FOR THE AUTOBIOGRAPHICAL MEMORY INTERVIEW AND MODIFIED CROVITZ TEST

Inter-rater crosstabulation table for the Autobiographical Memory Interview scoring

		Rater 2				
		0	1	2	3	Total
Rater 1	0	4				4
	1	1	7	1		9
	2			10	13	23
	3			1	8	9
	Total	5	7	12	21	45

Inter-rater crosstabulation table for the Modified Crovitz test Personal memories scoring

		Rater 2						
		0	1	2	3	4	5	Total
Rater 1	0	2	1					3
	1		1					1
	2			5	1			6
	3			1	1			2
	4					13	5	18
	5					4	26	30
	Total	2	2	6	2	17	31	60

Inter-rater crosstabulation table for the Modified Crovitz test Public memories scoring

		Rater 2						
		0	1	2	3	4	5	Total
Rater 1	0	7						7
	1		0					0
	2			4				4
	3				0			0
	4			2	1	29	3	35
	5					6	8	14
	Total	7		6	1	35	11	60