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Memory Deficits Before and After Unilateral Anterior Temporal Lobectomy:
A Comparative Study of Children and Adults

by

Kay Abony-Bencze, M.A.

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of
the requirements for the degree of

Doctor of Philosophy

Department of Psychology

Carleton University
Ottawa, Ontario
May 25, 1998

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A Comparative Study of Children and Adults”

Submitted by
Kay Abony-Bencze, M.A.

In partial fulfilment of the requirements for
The degree of
Doctor of Philosophy

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ABSTRACT

Neuropsychological test performance of 48 adult (19 left temporal lobe and 29 right temporal lobe) and 26 children (11 left temporal lobe and 15 right temporal lobe) were assessed pre and post unilateral anterior temporal lobectomy. Neuropsychological measures of intelligence, verbal memory, spatial memory, semantic memory, attention, achievement, executive functioning and perceptual functioning were obtained.

Following surgery the expected material specific memory deficit was observable only for the left temporal lobe groups. Verbal memory improvement following right temporal lobe was also observed. These findings support the hypothesis that declarative memory (as measured by the verbal memory tests) is dependent on the hippocampal memory system. No significant decline was observed in the right temporal lobe group following surgery on spatial memory measures suggesting an unconscious process of familiarity possibly evoking the nondeclarative memory system. Although sample size was small, tumour patients showed a similar pattern of performance to nontumour patients with the exception that tumour patients as a group initially performed at higher baseline levels. Results suggest that measures of intelligence, semantic memory, attention, achievement, executive functioning and perceptual functioning are unaffected by temporal lobectomy or by side of resection included.

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INTRODUCTION

The study of epilepsy, and the subsequent surgical resection of temporal lobes, provides a unique opportunity to study the hippocampal memory system as well as to examine the recovery of cognitive function. Seizures have been documented for centuries with the earliest references to complex partial seizures dating back to the early nineteenth century. At this time it was understood that complex partial seizures were distinct from generalized seizures and specifically related to a focal brain disease (Bright, 1831; Pritchard, 1822). Sixty years later Horsley first attempted a cortical resection for the relief of partial complex seizures. Surgery, as an alternative form of therapy, only began to be explored as a viable option after electrophysiological localization became available in the mid 1900's with the advent of the electroencephalogram in 1929 by Berger. Advances in neurophysiological research and the understanding of the human epileptic brain began with the work of Hughlings Jackson, Jasper and Penfield during the early and mid twentieth century (Penfield & Milner, 1958; Taylor, 1931).

There are many areas of cognitive functioning that can be examined following surgical resection of the cortex but perhaps the most frequent has been memory. The link between memory and epilepsy began with the now famous case of H.M. whose bilateral temporal lobectomy, including the removal of both hippocampi, resulted in a profound anterograde amnesia (Scoville & Milner, 1957).

Outcome studies have documented post-lobectomy cognitive functioning, but have done so by using different measures to evaluate the success of the surgical procedure such as reporting the number of seizures at the time of the post-operative

evaluation or employing life adjustment variables such as school success in the case of children and employment in the case of adults. Few formal long term studies exist which delineate the specific and sometimes very subtle memory deficits exhibited by patients who have undergone unilateral temporal lobectomy taking into account such intervening variables as age of onset, pre-surgical level of intellectual functioning, and whether surgery was performed during childhood or adulthood. All of these variables may have different implications for life adjustment, as well as for recovery of memory functioning.

In terms of recovery of function, the relationship between brain and behaviour following surgical resection is influenced mainly by three factors: (a) the size of the lesion, (b) the age of the patient, and (c) the length of time between diagnosis (which serves as a benchmark for onset although it is recognized that onset predates diagnosis) and resection (Kolb & Whishaw, 1990). Recovery is primarily better with smaller lesions, younger patients and shorter time periods between onset and resection.

In the current study the relationships of these variables were examined within the context of the currently accepted model of memory as proposed by Squire (1992) and Cohen and Eichenbaum (1993) (see Appendix A). This model proposes that memory functioning is comprised of two components: nondeclarative or implicit memory (e.g., procedural memory such as simple classical conditioning, preference, or habituation tasks) and declarative or explicit memory (e.g., information that is consciously retrieved from past learned experiences). An example of an implicit memory task is one in which a subject is shown a list of words after which the subject

is asked to participate in a perception task where words are presented very quickly and the subject is asked to identify each word. The subject is not told to remember the original list of words nor that the original list of words may help them in the identification phase of the experiment. Jacoby (1983) found that twice as many of the primed words (those words presented in the original list) were correctly identified as compared to the unprimed words. Declarative memory tasks, on the other hand, are those for which the subject is asked by the experimenter to recall a past experience such as recalling or recognizing words of which some were presented earlier. Declarative memory can be further subdivided into semantic memory (comprised of general knowledge and facts) and episodic memory (which is comprised of memory of past events which occur within a specific context). Squire (1992) has proposed that episodic memory is tightly linked to the hippocampal memory system and as such can be assessed by traditional neuropsychological tests of recall and recognition of verbal and spatial memory. On the other hand, semantic memory is tightly linked to a different memory system which is anatomically distinct from the hippocampal memory system.

Definition of Epilepsy

While there exists some discrepancy between studies, the condition of epilepsy is generally defined by the presence of at least two unprovoked seizures. That is, epilepsy refers to a transient period of abnormal cerebral excitability and synchronization of neuronal activity resulting in a sudden disruption to ongoing behaviour, movement, consciousness or other brain function, excluding those seizures provoked by an acute central nervous system insult, a systemic metabolic

derangement, or those that occur in the presence of fever (the latter are commonly referred to as febrile convulsions and are usually limited to very young children) (Bennett & Krein, 1989; Hauser & Hesdorffer, 1990). Seizures appear in various forms with and without loss of consciousness. A table of seizure type (originally defined in 1969, revised in 1981 and again in 1985 by the International League Against Epilepsy) is available in Appendix B. The remainder of this dissertation shall limit itself to a discussion of complex partial seizures (defined as seizures consisting of some specific motor or sensory alteration with impairment of consciousness).

Although the classification of complex partial seizures is always based upon EEG findings, it may in some cases be complicated by signs and symptoms of ictal manifestations such as, but not limited to, twitching, speech arrest, visual hallucinations or headaches. Surprisingly there is only one existing study that has examined the inter-rater reliability of neurologists in classifying seizures based on the patient's description of the seizure(s). This study found inter-rater reliability to be only between 12%-40% (Bodensteiner, Brownsworth, & Knapik, 1988).

The issue of definition gains importance when comparisons are made between studies. Methodological difficulties arise when one assumes that all persons with epilepsy within a specified population can be identified. Moreover, one can't assume that each group identified as epileptic is, in fact, epileptic. Some researchers have been known to include patients in their "epilepsy" group who have had febrile seizures and perhaps only one epileptic seizure (e.g., Van den Berg & Yerushalmy, 1969). Moreover, it is difficult to identify the true epileptic in this group because most patients are often prescribed antiepileptic drugs (AEDs) immediately following the diagnosis of

epilepsy.

A further complication arises when defining intractable seizures. Most centres define intractable seizures as "any seizures occurring while the person is documented as having an AED concentration of at least one standard medication in the usually effective range at the time of the seizure within one year after the onset of epilepsy" (Leppik, 1992, p. 9). However, one must recognize that within this definition there still exists a wide spectrum of severity (i.e., some patients may experience daily seizures while others may experience only occasional seizures). Appendix C cites variables most often associated with intractable seizures. These include seizure type, EEG etc. Leppik cautions against classifying seizures as refractory before a thorough consideration is made of the severity, frequency, and consequence of the seizure disorder for each patient. He cites the example of a machinist who was classified as having refractory seizures because he had one seizure every six months while on therapeutic doses of AEDs. Yet a patient of a residential facility who experiences the same clinical features as the above mentioned machinist may be considered to be well controlled. So when one is speaking of individual cases, the term "intractable" must also include a discussion of the patient's lifestyle. Inconsistencies in the definition of epilepsy and in the criteria for selection of subjects to studies make comparisons between studies more complicated, but not impossible as long as these differences are discernable in each study.

Incidence and Prevalence of Epilepsy

The single most common neurological disorder (across all age groups) in North America is epilepsy, with an overall incidence of 3.2% (Hauser & Hesdorffer, 1990).

Although most studies of incidence (the number of new cases within a given time frame) and prevalence (the number of active cases at any given point in time) come from the United States, Epilepsy Canada reported 14,000 newly diagnosed cases of epilepsy (adults and children) in 1993 (Epilepsy Canada, Health Statistics Report, 1994).

Seizures originating in one or both of the temporal lobes are probably the most common of all forms of epilepsy. Of this type, over 75% of temporal lobe epileptics experience their first seizure before the age of 20 (Bruni, 1987; Meyer, Marsh, Laws & Sharbrough, 1986; Vaernet, 1983). A more recent study by Cowan, Bodensteiner, Leviton and Doherty (1989) found that in 60%-86% of cases the onset occurred before they were 4 years old.

Adult Literature

Engel (1989) pointed out that within the adult sample there is a need for age adjusted prevalence and incidence rates. Engel based this conclusion on the findings which compared the incidence for epilepsy against age and type of seizure. He concluded that while the incidence of generalized epilepsy remained fairly constant through life, the incidence of complex partial seizures is highest before age 20 and after age 50.

It should be noted that prevalence rates may often be misleading due, in part, to the patient's degree of self-disclosure, how cases are selected, and what age group defines the sample (if indeed one is cited). Prevalence rates will be grossly underestimated when patients choose not to seek medical attention. This may be due to any number of reasons such as limited financial resources and/or social stigma. As

well, some individuals with seizures are reluctant to confirm their diagnosis during an interview or on a questionnaire thus again causing underestimation of prevalence rates. Beran, Hall and Michelazzi (1985), in a study investigating self-reporting of epileptics, reported that as many as 23% of known epileptics (based on information obtained from the medical record) denied having the disorder on a questionnaire sent to their homes. The prevalence rate can also vary depending on how cases were selected. That is, whether they were selected on the basis of questionnaires sent to the patient's home or on the basis of medical records. It should also be noted that within the adult population racial minorities have shown a greater prevalence of seizures over whites. Four studies have shown an increased prevalence of seizures among nonwhites (Cowan et al., 1989; Haerer, Anderson, & Schoenberg, 1986; Hollingsworth, 1978; Shamansky & Glaser, 1979). Whether this is a reflection of ethnicity or a result of socioeconomic factors (e.g., poorer prenatal care) requires further investigation (Haerer et al., 1986).

Child Literature

United States statistics estimate that children account for approximately 150,000 cases (approximately 15,000 cases in Canada) of active epilepsy (i.e., having had a seizure in the last five years or being presently on antiepileptic medication). Based on the 1980 census, this translates to slightly less than 1% of the children between the ages of 5-14 (Hauser & Hesdorffer, 1990). These data, however, do not include all of those children who are institutionalized. When these cases are included, they increase to 324,000 or 2% of the childhood population (Baumann, Marx, & Leonidakas, 1978). This states the prevalence rates of epilepsy between cerebral

palsy (.75%) and mental retardation (2.5%). Although, as yet unexplained, epidemiological studies of children and adolescents (Cowan et al., 1989) have documented a 1.34 greater prevalence of seizures in males than in females. The male excess in prevalence has been suggested to be related to the higher proportion of birth traumas reported by physicians attending male births.

Cognitive Functioning Related to Seizure History Characteristics

One of the problems with research studies in this area is the basis for classification or etiological grouping of subjects. The traditional selection factors of gender, age, and seizure type may not be sensitive enough to group subjects, and additional variables may be necessary to provide a more homogeneous sample. Of all of the potential variables that could be included, Dodrill's meta-analysis (1988) suggested that age of onset is of primary importance, as well as duration of the disorder and frequency of seizures. These three variables take into account the impact of the possible deterioration of cognitive functioning sometimes associated with chronic seizures as well the decline caused by the long term use of antiepileptic medication.

Age of Onset

Few studies report the correlations between age of onset and post-surgical neuropsychological outcome. The use of the Wechsler Intelligence Scales (Wechsler, 1981; 1974) is the most common method of assessing general intellectual functioning post-operatively. Studies which include age of onset as a variable (see Table 1) show that early onset is generally associated with lower scores on measures of general intelligence, particularly when the age of onset is below 5 years of age

(Dodrill, 1992; Farwell, Dodrill, & Batzel, 1985; Saykin, Gur, Sussman, O'Connor, & Gur, 1989; Woods, 1980). It should be noted that the Farwell et al. study was not limited to subjects having only complex partial seizures. Dodrill (1992b) reported that patients in the early onset of epilepsy group had a Full Scale IQ (FSIQ) that fell within the mildly retarded range (ranging from 70 to 79) whereas patients in the late onset of epilepsy group (adult onset) had an average FSIQ ranging from 90 to 109. Differences in terms of post-operative memory functioning were also documented. Patients in the early onset of epilepsy group with left temporal lobe resections (all were right handed) showed an unexpected decline in non verbal memory following resection (as well as the expected decline in verbal memory) while patients with right temporal lobe resections (both the early and late onset groups) showed improvements following resection in both verbal, and non verbal memory (Saykin et al., 1989).

Insert Table 1 about here

In contrast to the above, reports from studies of children who were epileptics but who were not candidates for surgery have suggested that age of onset is, in itself, not a significant factor affecting memory functioning (Jambaque, Dellatolas, Dulac, Ponsot, & Signoret, 1993). These conflicting reports of the importance of the age of onset suggest that age of onset may not be a single variable with a single effect on memory functioning. That is, while age of onset may be the same in two individuals, the time between onset and surgery/testing (i.e., illness duration) may vary and it may be this second variable that affects memory performance.

Table 1
A Summary of Studies Which Examine Seizure History Variables and Their Effect on Cognitive Functioning

Study	Variable	Effect
Dodrill (1992b)	Age of Onset	Age of onset accounted for 9% of the variance. Number of current medications accounted for 12% of the variance.
Saykin, Gur, Sussman, O'Connor, & Gur (1989)	Age of Onset	Early onset was associated with lower IQ: FSIQ $r=.64$, PIQ $r=.50$, VIQ $r=.59$ all $p < .01$)
*Farwell, Dodrill, & Batzel (1985)	Age of Onset, Duration, Frequency	Late onset was associated with higher IQ ($r=.30$, $p < .01$). Duration was inversely proportional to IQ ($r=.40$, $p < .01$). Frequency was inversely proportional to IQ ($r=.40$, $p < .01$)
Woods (1980)	Age of Onset	Early onset was associated with lowered VIQ and PIQ.
*Meyer, Marsh, Laws, & Sharbrough (1986)	Duration	Short duration was associated with greater the post-op improvement in PIQ & VIQ ($p < .02$).
Ladavas, Umiltà, & Provinciali (1979)	Duration	Longer duration was associated with lower scores on verbal and spatial learning.
Delaney, Rosen, Mattson, & Novelly (1980)	Frequency	Frequency had no significant effect on WMS verbal and nonverbal measures and recurring figures.
Dikman & Matthews (1977)	Frequency	High frequency was associated with lower IQ

* denotes those studies where subjects included children.

Duration of Seizure Disorder

Although the adult and the child literature are scant the effects of illness duration on cognitive outcome (see Table 1), four studies have reported a negative correlation between duration of seizure disorder and cognitive functioning (Farwell et al., 1985; Ladavas, Umiltà, & Provinciali, 1979; Meyer et al., 1986; Westerveld, Zawacki, Spencer, & Sass, 1993). An early study of adults by Ladavas et al. (1979) showed that patients who were diagnosed and tested within one year (short duration of seizure disorder group) performed significantly better on attentional tasks (e.g., Digit Span and Corsi block tapping) than patients who were tested well over a year after their initial diagnosis (the long duration of seizure disorder group).

On measures of general intelligence (Wechsler Intelligence Scale for Children-Revised; WISC-R, Wechsler, 1991), Meyer et al. (1986) found a significant correlation between the duration of the seizure disorder in children and measures of verbal and performance IQ. That is, the shorter the interval between the onset of seizures and surgery the greater the improvement in post-operative IQ scores. These findings were replicated by Westerveld et al. (1993) in a study where the average age at surgery was 14 years. A more favourable cognitive outcome was reported for the group who had the shorter duration of seizure disorder. It is generally thought that those patients who are operated on after 10 years of seizures will show poorer recovery of function following temporal lobectomy than those patients operated on before the crucial 10 year duration cutoff (Delaney, Rosen, Mattson, & Novelly, 1980).

Frequency of Seizures

The effect of frequency of seizures on subsequent cognitive functioning remains

controversial (see Table 1). One study reported poorer performance on measures of memory functioning in patients who had a higher frequency of seizures than those with a lower frequency of seizures (Dikman & Matthews, 1977). A similar pattern of performance was reported for general level of intellectual functioning. That is, as the frequency of seizures increases the level of intellectual functioning decreases (Dodrill, 1992; Farwell et al., 1985). However, as shown in Table 1, other studies do not support this finding (Delaney, Rosen, Mattson, & Novelly, 1980). Although a higher frequency of seizures may not always be associated with lower cognitive functioning, it could be argued that a higher frequency of seizures may result in more disruptions of mental functioning, the sequelae of which could last several days during which time there may be other seizures further disrupting learning (Trimble, 1987). At the present time there are no studies which link memory deficits and seizure frequency that contain a sufficiently large sample size to produce reliable results.

Management of Epilepsy

Pharmacological Intervention

Over the last half century, the clinical management of complex partial seizures has largely consisted of the use of antiepileptic drugs. Developed originally as an extension to the common sedative, the pharmacology of AEDs have progressed as knowledge of the chemistry of neurotransmitters has broadened. Whether functioning as an inhibitory neurotransmitter agonist or an excitatory neurotransmitter antagonist (Dreifuss, 1992; Macdonald & Meldrum, 1989), it is common to see a wide range of responses to any one drug over time. The seizure type response profile depends on drug tolerance and other factors such as alcohol use or sleep deprivation (Mattson,

1992).

Leppik (1992) and Bruni (1987) reported that although the majority of patients are well controlled on medication, as many as 20%-31% of epileptic patients (adults or children) are only partially controlled by AEDs. Lack of efficacy is due to difficulties arising from drug interactions, noncompliance, drug side effects, inadequate dosage level, and variables that may alter the absorption of the drug such as body weight, type of drug, or intractable epilepsy. In young children it may also be difficult to maintain a therapeutic level due to the inefficiency of the child's drug metabolizing system.

A considerable literature exists on the intellectual and cognitive effects of antiepileptic drugs. Table 2 reviews the effects of the seven most commonly prescribed anticonvulsant medications on cognition along with their behavioural side effects. The majority of the studies have focused on the examination of the effects of three drugs: carbamazepine (Tegretol), valproic acid (Depakene), and phenytoin (Dilantin).

Insert Table 2 about here

Researchers have documented that carbamazepine had no effect on memory or attention in samples of adult patients (Aikia, Kalviainen, Sivenius, Halonen, & Reikkinen, 1992; Gallassi, Morreale, DiSarro, Lugaresi & Baruzzi, 1992,). One centre has reported only slight psychomotor deterioration with this drug, as with all of the AEDs (Gillham, Williams, Wiedmann, & Butler, 1990). Studies of carbamazepine in children have produced a variety of findings. Forsythe et al. (1991) reported a definite

Table 2
Most Commonly Prescribed Anticonvulsant Medication

Generic Name (trade name)	Side Effects	
	Cognitive	Behavioural
1. Phenobarbital (Luminal)	Impaired STM and concentration	Lethargy and inattentiveness
2. Primidone	Side effects similar to phenobarbital, not as pronounced.	None
3. Phenytoin (Dilantin)	Impaired visuo-motor performance, attention, and STM	Fatigue and involuntary movements
4. Ethosuximide (Zarotin)	Impaired attention	Mood changes and drowsiness
5. Valproic Acid (Depakene)	Decreased attention	Drowsiness
6. Clonazepam (Klonopin)	None	Depression
7. Carbamazepine (Tegretol)	Impaired performance on memory tasks* and motor tasks	Irritability and agitation

* denotes findings in studies using children

(REF: Aikia et al., 1992; Aman et al. 1990; Dodrill, 1992; Forsythe et al., 1991; Gallassi, et al., 1992; Gillham et al., 1990; May et al., 1992)

decrease in memory functioning, while Aman, Werry, Paxton, Turbott, and Stewart (1990) reported an increase in attention span. Valproic acid and ethosuximide, on the other hand, were reported to adversely affect attention in adults (Gallassi et al., 1992). The effects of valproic acid are contradictory; one study using children showed that valproic acid actually improved auditory and visual memory (Forsythe et al., 1991). Several studies remarked on the adverse effect of phenytoin, phenobarbital, and primidone (to a lesser extent) on short term memory (STM), concentration, and general cognitive functioning of adult patients (Gallassi et al., 1992; Gillham et al., 1990; May, Bulmahn, Wohlhuter, & Rambeck, 1992) yet two studies reported no such effects for phenytoin in their samples of adult patients (Aikia et al., 1992; Dodrill & Wilensky, 1992). Likewise clonazepam was reported as having no serious cognitive side effects (Gillham et al., 1990). Taken together, all of these studies support the conclusion that the cognitive effects of AEDs, reflect only subtle changes (Aikia et al., 1992; Dodrill & Wilensky, 1992; Gillham et al., 1990; Meador, Loring, Huh, Gallagher, & King, 1990).

Methodological Considerations. In reviewing the literature on pharmacological intervention several methodological shortcomings are apparent. First, it can not be assumed that a patient group consists of a homogeneous sample of epileptic patients. Second, medication compliance, as with any drug prescribed for long term use, may become a problem. Third, a bias may exist in the selection of medication. When valproic acid was first introduced to the market it was used almost exclusively on the duller (below average IQ), more difficult to control patients (Dodrill, 1992a). Fourth, the neuropsychological measures selected to assess cognitive functioning may not accurately reflect what is proposed to be studied as is the case when timed tests are said to measure cognitive functioning. Dodrill (1992b), in a review of 40 studies,

concluded that the chance of finding an effect from an AED was as high as 85% when using timed tests but dropped to 43% when using non-timed tests. Is it then memory and attention that are being assessed or speed of response?

Surgical Intervention

Consideration for surgery is usually made after the failure of AEDs has been established. However, there are no international set of guidelines or criteria to establish AED failure. The variables that are considered important in establishing AED failure generally include the drug or combination of drugs have been tried, their respective dosages, and compliance of the patient. The extent of patient non-compliance has been estimated to run between 20% and 82% (Cramer, Mattson, Prevey, Scheyer, & Ouellette, 1989). Mattson (1992) and Engel (1989) suggest that a patient's seizures be described as intractable for a minimum of two years before consideration for surgery is made. The option of surgery comes from the understanding that a life of recurrent seizures, often accompanied by very high doses of a variety of drugs, could have serious detrimental effects on cognitive functioning, learning, self-esteem, and behaviour (Camfield et al., 1984; Dodrill, 1992b; Lesser, Lunders, & Wyllie, 1986; Meyer et al., 1986).

Surgery for the relief of intractable seizures in adults began in the mid 1900's at the Montreal Neurological Institute with the work of Dr. Penfield. However, only in the last twenty years has this form of intervention become acceptable as patients and physicians became aware of the potential benefits of surgery. Although certainly more common in the adult population, the option for surgical removal of the anterior temporal lobe for the relief of intractable seizures in children has become a viable option. With more centres equipped to perform this type of surgery, temporal

lobectomies for those under 20 years of age have increased six to ten fold in 1990 in the United States (Girvin, 1991). In Canada, the numbers are still small, but there are centres nationwide performing this type of surgery on children. Until quite recently the limiting factor in performing this type of surgery on children has been the relative uncertainty of the EEG to accurately identify the epileptogenic zone in patients below age 12 (Engel, 1987). However, the wide array of neuroimaging tools now available, such as magnetic resonance imaging, has allowed more candidates (even very young patients) to be considered for surgery by accurately identifying the affected temporal lobe (Engel, 1989). As seizures originating in the temporal lobe(s) account for the majority of complex partial seizures, and because the removal of the anterior portion of the temporal lobe is a surgically straightforward procedure it has been cited as the most frequent form of cortical resection for intractable epilepsy (Feindel & Rasmussen, 1991). The procedure requires a 4.5 cm to 6.0 cm resection removing the pes, hippocampal gyrus, amygdala, uncus, and either the anterior few millimetres of the body of the hippocampus or more of the body of the hippocampus depending on which hemisphere is being resected (dominant or nondominant hemisphere). (See Appendix F for more details).

Transient complications of cerebral edema, new neighbourhood seizures, and psychosis have been reported in the early post-operative period (Andermann, 1977; Channon & Polkey, 1990; Ventureyra & Higgins, 1993). Permanent outcome complications may include contralateral hemiparesis, superior homonymous quadrantanopsia, and memory deficits (Meyer et al., 1986; Ventureyra & Higgins, 1993). Present epidemiological reports indicate that morbidity resulting from an anterior temporal lobe resection is approximately 5% to 16% while mortality resulting

from the procedure runs at less than 1% (Engel, 1987; Green & Pootrakul, 1982).

Although not consistent across all centres, the following criteria are commonly considered in selecting surgical candidates. First, it should be established that the seizures are indeed intractable. Second, the seizure disorder should have a focal onset. Third, the patient should not be functioning intellectually in the severely retarded range (IQ of 69 or below) as this may be indicative of diffuse brain damage. Finally, there should be no indication of a progressive medical condition (Blume & Kaibaba, 1991).

Reports of success or failure of anterior temporal lobectomy in both the adult literature and the child literature have usually been expressed in terms of seizure control. Engel (1987), in a review of 40 adult outcome studies ($n=2336$), calculated that over 50% of the combined sample were identified as seizure free at one year follow-up with a further 28% classified as improved. Ventureyra and Higgins (1993) reported that 87% of their child sample were seizure free at post-operative evaluation. This is consistent with the findings of Blume and Kaibara (1991) who reported a 90% reduction in seizure quantity in a large ($n=48$) retrospective study of children (follow-up data ranged from 1 to 15 years post-operatively). Other centres have reported somewhat lower success rates. Meyer et al. (1986) reported that 75% of anterior lobectomy patients in his sample of children ($n=50$) were seizure free at follow-up. Green and Pootrakul (1982) reported that 80% of anterior lobectomy patients in his sample of children ($n=32$) were seizure free at follow-up. Vaernet (1983) reported that only 61% of his anterior temporal lobectomy sample of adolescents ($n=33$) were seizure free at follow-up.

The 20% difference between studies may be accounted for by the differences in

what is understood as "seizure free". Does the term imply completely seizure free since surgery or can the patient who still experiences auras also be included?

Moreover, the acquisition of these data is dependent on the subjective impressions of the patient. Furthermore, it has been established that seizure patterns may change over time. That is, the relationship between anterior temporal lobectomy and seizure control is a dynamic one (Engel, 1987). Notwithstanding these considerations, there is a higher percentage of children who are seizure free following resection than adults at one year follow-up.

Only a small number of studies have looked at the long term benefits (greater than 12-24 months post-resection) of an anterior temporal lobectomy, and fewer still have looked at the benefit of surgery during childhood as opposed to adulthood. Only a single study exists comparing the outcome of children with adults. Mizrahi, et al. (1990) reported that at 8 years follow up, 69% of the adult sample were experiencing difficulties in social adjustment or in gaining employment while only 20% of the child sample were experiencing difficulties in education or vocational progress. Those patients, operated on during childhood, experienced a better overall outcome, as defined by quality of life ($n=14$ adults, $n=8$ children). An earlier study of children and adolescents (Vaernet, 1983) reported that 14% more children were classified as seizure free than adolescents at follow up. In summary, these studies have concluded that younger patients had better outcome. These studies did not, however, comment on the fact that there is more social and psycho-educational support for children in school than for adults who are employed.

In an attempt to find a variable to reliably predict the success of anterior temporal lobe resection, Lieb, Rausch, Engel, Brown, and Crandall (1982) designed a

correlational study to examine the relationship between success of surgery and level of intelligence. He concluded that patients with average or above average IQs achieved greater reduction in seizure quantity following resection than patients whose IQ was below average. This finding was replicated by Blume and Kaibara (1991). Another approach by Dodrill (1992) attempted to predict successful outcome based on EEG findings (i.e., a single foci pre-operatively). His results showed that successful surgery (defined as seizure free) can be predicted up to 73% of the time based solely on EEG findings, but if data from the neuropsychological assessment were added predictability rose to 80%. This rate dropped, however, to 63% at 5 year follow-up, thus indicating a substantial loss in predictive power over the long term as well as demonstrating the complex nature of prediction. It is the combination of many factors such as EEG, neuropsychological data, age of onset, illness duration, seizure control, and pathology that may each contribute in the final equation for predicting whether resection will indeed prove beneficial in the individual treatment of intractable complex partial seizures.

NEUROPSYCHOLOGICAL FINDINGS

Introduction

The first reports of post-operative changes in cognitive functioning following temporal lobectomy were published in the mid 1950's, and were based on adult case studies (Milner, 1958). Intelligence tests were and still are commonly used to assess cognitive deficits including memory. Several studies (Smith & Milner, 1989; Ellenberg, Hirtz & Nelson, 1986) have shown that Wechsler IQ scores are normally distributed for adults and children with complex partial epilepsy. While another study (Dikman, Matthews, & Harley, 1975) showed that as a group, children with epilepsy exhibit

lower IQ scores than children who do not have the disorder. All of the findings from these studies have been based on the summarized IQ scores (i.e., FSIQ and to a lesser degree PIQ and VIQ), and did not include a breakdown by individual subtests. This is not in keeping with the present more analytic neuropsychological approach which emphasizes the pattern of strengths and observed weaknesses with the individual subtests. Global measures, according to Rausch (1992), are too general since "the epileptic process has a subtle effect on neuropsychological scores; therefore, interpretations of the neurological scores must rely heavily on the overall pattern of performance" (p. 77).

The study of discrete cognitive abilities, such as memory, and how it may be affected by a disorder such as epilepsy began in the 1960's, and has continued to the present as newer and more valid tests and measures are being used, as medication regimes change, and as more patients are opting for surgical removal of epileptogenic tissue. Although tests of memory functioning are correlated with general intelligence, they have been shown to be selectively affected by temporal lobectomy.

Although reports of memory changes following resection have been documented for over four decades, little substantive data regarding any aspect of recovery of function have emerged. This is most evident in the child literature. Despite the importance of long term recovery, very few studies have made remarks regarding the recovery of memory following temporal lobectomy (Blakemore & Falconer, 1967; Brockway, Follmer, Greenhoot, & Follmer, 1993; Milner, 1958). Brockway et al. (1993), in a comparative study of pre-operative versus post-operative cases, concluded that since scores of post-operative cognitive functioning did not differ significantly from pre-operative ones, recovery of function was minimal. This conclusion may have been

premature since his sample size was relatively small ($n=18$).

Methodological Considerations

Before examining in detail the specific nature of cognitive deficits after resection, several methodological issues need to be presented in order to allow comparisons of results across studies. First, the criteria for diagnosing epilepsy and localizing a seizure focus may not be standardized. Second, each centre may contain a unique patient population resulting in patient selection biases, with the most experienced centres drawing the most difficult cases. Third, pre-operative criteria for surgical candidates may not be uniform even though many centres employ similar protocols. These protocols usually include a global measure of cognitive functioning, a measure of mental control to identify attentional deficits, lateralization tests, and specific tests of memory (verbal and spatial). This type of approach to neuropsychological assessment, as part of the multi-disciplinary pre-surgical evaluation, is used as a means to identify and/or to confirm dysfunctional or impaired cortex. Fourth, while a specific surgical technique is commonly agreed upon, many variations may occur which ultimately affect outcome. Fifth, follow-up assessments may be carried out at varying times, perhaps affecting outcome. For example, some patients may experience a seizure free period of undetermined length prior to the resumption of seizures thus causing them to be misclassified as part of the seizure free group. Lastly, the definition of successful outcome may not be uniform.

There are also a number of methodological concerns centred around tests of general cognitive functioning such as intelligence tests. First, practice effects have been shown to produce an overall increase in IQ scores in patients who have been retested several times. Moreover, in many studies the inter-test interval may be short

thereby maximizing any practice effects (Lezak, 1995). Second, several of the subtests frequently used are timed, such as those included in the performance IQ subtests.

Tests aimed at assessing memory functioning have their limitations as well in that there often is a high correlation between memory tests and tests of intelligence suggesting that the same abilities are being tapped (Lee, Loring, & Thompson, 1989). Furthermore, some of the measures that have been used may not be adequately standardized or are standardized on small sample sizes and have poor normative data. For example, the Luria-Nebraska Neuropsychological Battery which contains 11 memory tests has only been normed on adult samples yet is frequently administered to adolescents as young as 13 years of age (Tramontana & Hooper, 1988). There is also concern regarding the validity and reliability of some currently used measures. For example, some of the tests of spatial memory (e.g., immediate recall on the Benton Visual Retention Test) load more heavily on a visual-perceptual-motor factor than on memory yet is frequently cited as a test of memory (Larrabee, Kane, Schuck, & Francis, 1985; Lee et al., 1989). There is also concern regarding practise effects from one testing session to the next. At the pre-operative assessment of the Rey-Osterrieth Figure patients are not told that they will be asked to redraw the figure from memory at a later time yet at the post-operative assessment the patient may recall the memory requirements of this test. The learning paradigm then changes from incidental learning to intentional learning. In fact, while this is not a practise effect there is a similar effect.

Studies of Outcome in Adults

Temporal Lobe Involvement

Many results from the early studies of complex partial seizures with a unilateral

temporal lobe focus in the adult population suggested a material specific memory loss. A left hemisphere focus (usually considered to be the dominant hemisphere in right handed individuals) was expected to result in a verbal memory loss, while a right temporal lobe focus (usually the non-dominant hemisphere in right handed individuals) was expected to result in a spatial memory loss (Blakemore & Falconer, 1967; Kimura, 1963; Rausch & Crandall, 1982). Recognition memory for words and faces (Warrington, 1984) and measures of verbal and non verbal supraspans have consistently differentiated between right and left temporal lobe involvement (Dennis, Farrell, Hoffman, Hendrick, Becker, & Murphy, 1988; Fedio & Mirsky, 1969).

Temporal Lobe Resection

Spatial memory deficits were consistently observed only following right temporal lobectomy (Jambaque et al., 1993). Wyllie et al. (1991) reported that 45% of left temporal lobectomy patients showed at least a 10% decline in verbal memory after surgery while only 18% of right temporal lobectomy patients showed a similar decline in spatial memory. Leonard (1991) reported post-operative scores for left temporal lobectomy patients declined more on measures of verbal intelligence than did scores for right temporal lobectomy patients on comparable baseline measures of non verbal skills (Pre-op VIQ: LT=105 RT=106, post-op VIQ: LT=95 RT=105). Yet when other variables were introduced, such as neurosurgical outcome, left temporal lobectomy patients (N=130) for whom the surgery was successful (i.e., seizure frequency was reduced by at least 75%) had follow-up testing scores that were almost at pre-operative levels. Seizure frequency had no effect for the right temporal group.

Loring (1993) divided individuals into two groups based on age (less than 35 years of age and greater than or equal to 35 years of age). Only the older left

temporal lobectomy group showed a significant deficit in verbal memory functioning. In fact, the older right temporal lobectomy group actually improved in measures of visuospatial memory after resection. Naugle, Chelune, Cheek, Lunders, and Awad (1993) also reported a greater deficit in memory functioning following left temporal resection as opposed to right temporal resection on standard measures of memory (e.g., WMS-R). However, this dichotomy disappeared when subjective measures of memory were used such as memory questionnaires. In summary, it appears that it is the older patient who is continuing to seizure after left temporal resection who is at greatest risk for showing a deficit in memory functioning post-operatively.

Some studies have remarked on the presence or absence of sex differences with respect to neuropsychological outcome following temporal lobectomy. Trenery, Jack, and Ivnik (1993) reported that post-operatively only the left temporal lobectomy males showed a significant decline in cognitive functioning as compared to left temporal lobectomy females, right temporal lobectomy males and females. McGlone (1992) observed that only left temporal adult males showed a significant decline in verbal IQ scores postoperatively. This finding was interpreted to be due to a possible gender difference for verbal representation.

Premorbid level of intelligence may also have an effect on post-operative level of memory functioning. Chelune, Naugle, Lunders, and Awad (1991) showed that patients (n=42) with above average pre-operative IQ scores (FSIQ of 110 to 119) showed the greatest decline in post-operative memory functioning; however, this was only evident in the left temporal group. In contrast, those patients scoring in the borderline range of cognitive functioning improved by an average 10% post resection; however, this was only documented in the left temporal lobectomy group. This study

was unique in that post-operative findings were reported as a function of premorbid intelligence. Girvin, McGlone, McLachlan, and Blume (1987) reported that three patients with bitemporal lobe involvement based on pre-operative neuropsychological assessment, EEG, and sodium amytal testing showed no decline in memory functioning one year post-operatively, and were not globally amnesic immediately following the resection. All three patients were functioning in the borderline or mild retardation range intellectually before resection. Cross modality improvements have also been noted in samples of well controlled post resection patients. Novelly et al. (1984) and Rausch and Crandall (1982) found that the right temporal lobe group improved in rote verbal memory following surgery. Similarly, those in the left temporal group improved in non verbal memory following surgery.

Summary

The literature suggests that adult patients exhibit a greater decline in performance on neuropsychological testing following a left sided resection than following a right sided resection. However, performance (particularly for a left sided resection) can be effected by how well subsequent seizures are controlled post-operatively, premorbid level of intellectual functioning, gender, and age.

Studies of Outcome in Children

Temporal Lobe Involvement

A comprehensive review of studies of children with unilateral temporal lobe epilepsy who are not surgical candidates shows that they exhibit a typical pattern of material specific deficits. Children with seizures originating from the left temporal lobe typically showed poor auditory and verbal memory, particularly on measures of delayed verbal memory (Jambaque et al., 1993; Saykin, Gur, Sussman, O'Connor, &

Gur, 1989). Children with seizures originating from the right temporal lobe typically showed poor spatial memory although performance did not appear to worsen on measures of delayed spatial memory (Jambaque et al., 1993; Cohen, 1992).

Temporal Lobe Resection

Unlike the adult samples, material specific deficits in the child sample were generally observable both before and after resection of the temporal lobe although studies which have documented post-resection outcome of children have been few. Only one study did not corroborate these findings. Camfield, Gates, Ronen, Camfield, Ferguson, and MacDonald (1984) reported that the laterality patterns exhibited by adult seizure patients post-operatively on the Wechsler subtests were not always evident in children. In a review of children with either right or left temporal lobe resection they found no significant differences between the groups on measures of intelligence, achievement, or memory functioning. The arithmetic subtest was the only subtest that served to differentiate between the two groups, with left temporals performing significantly worse than right temporals post-operatively. However, in this sample most of the patient's seizures were well controlled by medication.

Some studies comparing pre-operative versus post-operative data have concluded that there is no greater decline following resection in children (Meyer et al., 1986). Others have observed that some measures actually improve post-operatively possibly due to a decrease in medication. Digit symbol (a measure of psychomotor speed and fine visual-motor coordination) is one such measure (Oakes, Swartzwelder, Santos, & Thompson, 1993). Only one study reported gender differences in children on the Wechsler Intelligence Scales. Meyer et al. (1986), noted that post-operatively females improved by an average of 4.9 points where males

declined by an average of 3.5 points.

One difficulty in interpreting data collected from children is that often normal developmental trends are ignored. Gilliam, Fletcher, and Levin (1986) in a study of 177 normal children showed that different memory functions develop at different ages. Spatial memory, for example, only begins to show a linear relationship with age after the age of 8.

Summary

Studies of children undergoing temporal lobectomy have a material specific memory loss of verbal memory and spatial memory. Moreover, these studies show that, unlike the adult population, these observed deficits are not always exacerbated following resection. There is also evidence to suggest that females do better than males in the child sample post-operatively on measures of intelligence and verbal memory.

CURRENT EXPERIMENT

Purpose

The purposes of this archival study were threefold. First, a detailed documentation of the pattern of memory deficit(s) exhibited by adults and children after unilateral temporal lobe resection is provided by reviewing the pre-operative and post-operative neuropsychological assessments of 48 adults and 26 children. To date there are only a handful of studies that include children. The outcome variables used in these studies have usually been limited to VIQ, PIQ, FSIQ, and WMS memory quotient. All of these measures may be too global to be discriminative. Consequently, a more detailed examination of their neuropsychological profiles will be undertaken. Second, the current study examined the impact of pre-operative level of functioning, gender,

age of onset, side of focus, duration of the disorder, and post-operative seizure frequency on cognitive functioning following temporal lobectomy in both the adult and the child samples to determine their relative predictive value for episodic memory functioning. The final goal of this study was to identify those variables which were good predictors of post-operative memory and cognitive functioning for each sample. These results may reveal variables which could reliably predict good cognitive outcome following temporal lobe resection. These findings may have important implications in the selection process for suitable surgical candidates. Specifically, if the results of this study support the proposed hypotheses they could provide further evidence that early surgical intervention is desirable.

Method

Participants

As part of my two year employment at University Hospital, London, Ontario (under the supervision of Dr. McGlone) pre-operative and post-operative data were collected for 48 adult patients who had undergone either right or left temporal lobe resection for the relief of intractable seizures (all adult patients were English speaking). These data were combined with the pre-operative and post-operative data available for a group of 26 children ranging in ages from 5 to 19 years (contributed by Dr. Knights) that have undergone similar resection over the last decade at Children's Hospital of Eastern Ontario (four of the children were bilingual).

Inclusion / Exclusion Criteria.

Inclusion: Criterion for inclusion into this study was limited to those patients who are known to have speech lateralized to the left hemisphere based on a

hand preference questionnaire and intracarotid sodium amobarbital test (i.e., WADA procedure).

Exclusion: Patients who were known to have seizures originating from both temporal lobes were excluded. Patients whose intelligence quotient was known to be in the severely retarded range (IQ below 69) were also excluded. Patients where the etiology of the seizures was classified as tumour (n=7 adults and n=7 children) were included in this study. Due to the small sample size of the tumour patients only descriptive analyses were performed.

Chart Review

On the basis of the previous reported studies, the following variables were considered to be relevant to the study of cognitive functioning before and after anterior temporal lobe resection. The first six variables were obtained by a review of the hospital charts, including neuropsychological records, patient's history, neurology notes, neuroradiological reports, neurosurgical reports, and pathology reports.

1. Basic demographical data (age, gender, years of education, age at testing, age at surgery, and post-operative seizure frequency).
2. Age of seizure onset (if unavailable from the patient's history, the date of diagnosis was used).
3. Amount of Tissue Resected. Although a standard amount of temporal lobe was resected for all patients in both samples (4.5 cm -6.0 cm) via en bloc surgical resection, (Appendix F) slightly more or less tissue was resected depending on whether it was the dominant or nondominant hemisphere, and in rare cases due to contraindications from pre-operative studies.

4. Illness duration, defined as the interval between the onset of diagnosis of epilepsy and time of surgery.
5. Etiology, consisting of nontumour or tumour.
6. Seizure frequency post-operatively (categorized into four groups as proposed by Lesser, Lunders, & Wyllie, 1992):
 - a) seizure free with occasional auras
 - b) less than 2 seizures per year
 - c) significant seizure reduction
 - d) no appreciable change

Neuropsychological Tests

The measures selected reflect neuropsychological functioning in eight major areas: general intellectual functioning, verbal memory, spatial memory, semantic memory, attention, achievement, executive functioning, and perceptual functioning. Although several tests were not identical in both samples, similar attributes were measured by the tests selected. As well, these tests have been demonstrated to be reliable and valid measures of the constructs they are said to measure (Lezak, 1995).

The following tests which are commonly used clinically to assess cognitive functioning were selected from the pre-operative and post-operative assessments administered to patients at London University Hospital and Children's Hospital of Eastern Ontario as part of their pre-operative and post-operative evaluations.

Intelligence

Wechsler Intelligence Scales (WAIS-R or WISC-R). (Wechsler, 1981; 1974a).

Eleven subtests were used to obtain an overall Full Scale IQ (FSIQ). These subtests include six verbal subtests (Information, Digit Span, Similarities, Arithmetic, Vocabulary, and Comprehension) and five performance subtests (Picture Completion,

Picture Arrangement, Block Design, Object Assembly, and Digit Symbol). The administration of the Wechsler Intelligence Scales followed the procedure outlined in the WAIS-R and WISC-R manuals.

Verbal Memory

Wechsler Memory Scale. (Wechsler, 1974b). This memory scale, comprised of verbal, and non verbal memory subtests (Information, Digit Recall, Logical Memory (immediate and delayed), Paired Associates (immediate and delayed), and Visual Reproduction), was administered to the adult group. For Logical Memory the patient was asked to recall two stories immediately after each story was presented and after a 45 minute delay (revised version by Russell, 1975). The scoring procedure for Logical Memory followed the procedure outlined in Kimura's Norms manual (Kimura, 1984) which allowed one point for each phrase that was recalled verbatim and a half point if a major segment was recalled verbatim. An average score of both stories was calculated with a maximum score of 22. For the Paired Associate task a list of words was presented two at a time following which the first word of each pair was given and the patient was then asked to recall the second word of the pair. Three learning trials and a delayed retention trial were employed. Scoring for the Paired Associate immediate condition followed the procedure outlined in Wechsler's manual where 6 of the 10 pairs of words were classified as "easy" and credited with a half point each, while the remaining 4 pairs of words which were described as "hard" are scored as a full point. A maximum score of 21 was possible for the immediate condition. Scoring for the delayed condition followed the Montreal Neurological Institute's revision (Taylor, 1988) which used the first word of each pair in the second presentation to illicit recall

and credited one point for each pair recalled regardless of its level of difficulty for a maximum score of 10.

Recognition Memory Test: Words. (Warrington, 1984). This memory test was administered to the adult sample. Fifty words were initially presented one at a time. Upon viewing each word the patient was asked whether they thought the word was pleasant or unpleasant. Word pairs were then presented where the patient was then asked to point to the word which was in the initial set for a maximum score of 50.

Sentence Memory Test. (Benton, 1962). This memory test was administered to the child sample. Twenty-five sentences in increasing difficulty were presented one at a time via a tape recorder following which the child was asked to repeat each sentence. A score of 1 point was given for each sentence recalled verbatim (no half points were given for partially correct responses) for a maximum score of 25.

Spatial Memory

Rey-Osterrieth Figure. (Rey, 1941 and elaborated by Osterrieth, 1944) . This test of spatial memory was administered to the adult sample. After a 45 minute delay (modified version by Taylor, 1969, 1979) the patient was asked to recall the complex figure copied earlier and to reproduce it. The delay condition was scored by awarding 1/2 point, 1 point, or 2 points, depending on accuracy and position, to each of 18 scorable units (as outlined in the original test) for a maximum of 36 points (Lezak, 1983).

Memory of the Tactual Performance Test. (Halstead, 1947). This test was administered to the child sample. The child was blindfolded and asked to place blocks of various shapes in their corresponding spaces in a form board, first with the preferred hand, then with the nonpreferred hand, then with both hands. The blindfold

was then removed and the child was asked to draw a picture of the board from memory. The memory component of this test was calculated by awarding a full point for each shape correctly drawn (including the shape's position relative to the other shapes on the board) for a maximum score of 6 (for children under 8 years of age and younger) or 8 (for children who were older than 8 years of age).

Semantic Memory

Vocabulary subtest of the WAIS-R or WISC-R. Factor analysis of the Wechsler Scales (Kaufman, 1979; Sattler, 1988) has identified the Vocabulary subtest as loading heavily on the verbal knowledge factor thereby providing a test of semantic memory.

Attention

Arithmetic and Digit Span subtests of the WAIS-R or WISC-R. Factor analysis of the Wechsler Scales (Kaufman, 1979; Sattler, 1988) has identified an attention factor with Arithmetic and Digit Span as the major subtests for this factor.

Achievement

Wide Range Achievement Test-Revised. (Jastak & Wilkinson, 1984). This achievement test for reading (articulation) was available for both the adult and child samples. Each word correctly read was awarded one point.

Executive Functioning

Wisconsin Card Sorting Test. (Berg, 1948). This test is a measure of concept formation and the ability to shift and maintain a set (Spreeen and Strauss, 1991) and was available for the adult sample. Four stimulus cards were placed in front of the patient who was then given a stack of 128 cards. The patient was asked to sort the cards using the stimulus cards with the examiner determining whether the cards

placement was correct or not. The examiner switched categories after 10 correct consecutive responses without informing the patient of the switch. The categories were colour, form, number, colour, form, and number. The number of categories achieved was scored to a maximum of 6.

Oral Fluency. (Benton, 1968). This test was administered to both the adult sample and the child sample. For the adult sample the patient was asked to name as many words as possible beginning with the letter "d". One point was given for each correct word. For the child sample the patient was asked to produce as many words as possible beginning with the letter "p" and then with the letter "c". One point was awarded for each correct word and the total score was the mean of both trials.

Category Test. (Halstead, 1947). This test is a measure of concept formation and was available for the child sample. Upon viewing slides of geometrical figures and designs the patient was asked to classify each figure determining if the figure made them think of the number one, two, three or four. Feedback was immediately given via a bell if the response was correct or a buzzer if it was not. Each time the subtest was changed the patient was told that the "idea" underlying the classification may have changed. The score was the total number of errors. For children under 8 years of age 80 slides were presented and for children who were over 8 years of age 168 slides were presented.

Perceptual Functioning

Picture Arrangement and Picture Completion subtests of the WAIS-R or WISC-R.

Factor analysis of the Wechsler scales (Kaufman, 1979; Sattler, 1988) has identified a perceptual organization factor with Picture Arrangement and Picture Completion as the

major subtests of this factor.

Rey-Osterrieth Figure: Copy. (Rey 1941 and elaborated by Osterrieth, 1944).

During the copy phase of this test the patient was asked to copy a complex figure placed in front of him/her. Scoring involved awarding 1/2 point, 1 point or 2 points depending on accuracy and position to each of 18 scorable units for a maximum of 36 points (Lezak, 1983).

Hypotheses

On the basis of the data and theoretical assumptions presented in the literature review contained here within, the following hypotheses were tested.

Hypothesis 1: It was expected that global measures of Intelligence would not show pre-operative differences between left and right temporal lobe groups in either the adult or child samples.

Hypothesis 2: It was expected that both samples of patients with left temporal lobe involvement would exhibit a verbal memory deficit pre-operatively when compared with those with right temporal lobe involvement.

Hypothesis 3: It was expected that both samples of patients with right temporal lobe involvement would exhibit a spatial memory deficit pre-operatively when compared to those with left temporal lobe involvement.

Hypothesis 4: It was also expected that a resection of the left temporal focus for the child sample would produce a verbal memory deficit unchanged from that seen pre-operatively, while an exacerbation of the verbal memory deficits already present would be expected for the adult sample following resection. Performance of the right temporal lobe adult and child samples on would be expected to be unchanged on

measures of verbal memory after resection.

Hypothesis 5: It was expected that both samples would exhibit a spatial memory deficit following resection of the right temporal lobe. Performance of the left temporal lobe adult and child samples would be expected to be unchanged on measures of spatial memory after resection.

Hypothesis 6: Performance on measures of semantic memory, attention, achievement, executive functioning, and perceptual functioning were expected to be within the normal range for both samples, pre-operatively and post-operatively.

Hypothesis 7: It was expected that post-operative outcome (verbal and spatial memory) would be better for younger, female patients who were operated on soon after the onset of seizures, who had pre-operative intelligence scores at or below average (but not in the severely retarded range), and whose seizures were well controlled post-operatively.

Analyses

The WISC-R, WAIS-R, WMS-R, RMT (Recognition Memory Test), and the WRAT-R were analysed using standard scores, which is the traditional method of reporting these scores. Since a portion of the scores under investigation in this study were age varied it was necessary to transform the child data into z standard scores using age graded normative data (means and standard deviations) available from Knights and Norwood (1977), and Spreen and Strauss (1991) before beginning any statistical analyses.

Preliminary means and standard deviations were calculated for each variable. This was followed by a repeated measures analysis of variance in order to compare

pre-operative functioning with post-operative functioning.

In order to confirm the existence of a material specific memory deficit (hypotheses 1 and 2) pre-operatively an analysis of variance was carried out. Determination of whether there was a change in the material specific memory deficit post-operatively used a repeated measures analysis of variance (hypotheses 3 and 4).

In order to confirm that frontal lobe and parietal lobe functioning remained intact repeated measures analysis of variance were carried out (hypothesis 5).

To determine which variables may serve as predictor variables, multiple regression analyses were carried out (hypothesis 6).

Missing scores were replaced by inserting the corresponding mean of the standardized scores.

Results

Demographics

Patient demographics for right and left temporal lobe groups were compared for the adult and child samples using a series of two tailed t-tests with an alpha level set at .05. As presented in Tables 3 and 4, there were no significant differences between the left temporal and right temporal lobe groups on basic demographics including age, gender, age of onset, duration of the seizure disorder, and years of education for either sample.

Insert Tables 3 & 4 about here

Psychometric Data

The psychometric data for the adult and child samples were analysed

Table 4
Patient Characteristics (Child Sample)

	Left Temporal		Right Temporal		<u>p</u>
	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>	
Gender (M/F)	7 / 4		7 / 8		
Age (years)	12.5	3.7	14.4	3.4	ns
Education (years)	7.1	3.5	8.3	2.9	ns
Age at Onset (years)	6.9	5.5	6.2	4.4	ns
Duration (years)	6.0	4.9	7.9	5.4	ns

Note. Duration is defined as the number of years from onset of seizures to surgery

separately for measures of intelligence, verbal, spatial, and semantic memory as well as for measures of attention, achievement, executive functioning, and perceptual-motor functioning. Comparisons were then made between the two samples. Finally, regression analyses for the total sample were conducted.

Raw scores on all dependent measures were initially plotted onto histograms to ensure that the assumptions of normality, homogeneity of variance-covariance matrices, and linearity were met. This was accomplished by inspecting the descriptive statistics of each variable, checking for skewness and outliers, plotting scattergrams, and checking for high Pearson correlations. An alpha level of .05 was used for all statistical tests to determine significance.

Intelligence

Adult Sample. Mean (SD) standard scores (intelligence scores are traditionally reported as standard scores) for pre-operative and post-operative intelligence scores are shown in Figure 1 (Table.5 of Appendix H). Performance on all three composite scores (FSIQ, VIQ, and PIQ) for both the pre-operative and post-operative assessments for the adult sample fell within the low average to average range.

 Insert Figure 1 about here

The question of whether patients with left temporal lobe involvement could be differentiated from patients with right temporal lobe involvement on the three composite scores of intelligence tested pre-operatively was addressed using ANOVA analyses. These analyses showed no significant effect for any of the composite scores. VIQ minus PIQ was calculated to determine if there was a clinical indication for lesion

Figure 1. Pre-Operative versus Post-Operative Intelligence Scores (Adult Sample)

localization. This measure was not significant.

Repeated measures ANOVAs were used to compare the pre-operative scores with the post-operative standard scores for intelligence (see Figure 1). The results indicated that the composite score of FSIQ was unaffected by resection for both left and right temporal lobe groups (Group: $F(1,46) = .01, p > .05$; Testing: $F(1,46) = .01, p > .05$; Group x Testing: $F(1,46) = .13, p > .05$). The results likewise showed that the composite score for PIQ was also unaffected by resection for both left and right temporal lobe groups (Group: $F(1,46) = .00, p > .05$; Testing: $F(1,46) = .91, p > .05$; Group x Testing: $F(1,46) = .58, p > .05$). Similarly, the composite score for VIQ was unaffected by resection for both the left and right temporal lobe groups (Group: $F(1,46) = .02, p > .05$; Testing: $F(1,46) = .76, p > .05$; Group x Testing: $F(1,46) = .07, p > .05$).

Child Sample. Mean (SD) standard scores for pre-operative and post-operative intelligence scores are shown in Figure 2 (Table 6 in Appendix H). The range of performance for all three composite scores for both the pre-operative and post-operative assessments for the child sample fell within the low average to average range.

ANOVAs showed no significant effect of side of focus pre-operatively for any of the three composite scores of intelligence. VIQ minus PIQ was calculated to determine if there was a clinical indication for lesion localization. This measure was not significant.

Insert Figure 2 about here

Repeated measure ANOVAs were used to compare the pre-operative scores

Figure 2. Pre-Operative versus Post-Operative Intelligence Scores (Child Sample)

with the post-operative standard scores. The results indicated that the composite score of FSIQ was unaffected by resection for both left and right temporal lobe groups (Group: $F(1,24) = .52, p > .05$; Testing: $F(1,24) = .31, p > .05$; Group x Testing: $F(1,24) = .00, p > .05$). The results likewise showed that the composite score of PIQ was unaffected by resection for both left and right temporal lobe groups (Group: $F(1,24) = .02, p > .05$; Testing: $F(1,24) = .20, p > .05$; Group x Testing: $F(1,24) = .20, p > .05$). The composite score of VIQ was unaffected by resection for both the left and right temporal lobe groups (Group: $F(1,24) = 1.90, p > .05$; Testing: $F(1,24) = 1.40, p > .05$; Group x Testing: $F(1,24) = .17, p > .05$).

Summary.

In summary, both the adult sample and the child sample composite scores of global intelligence failed to differentiate between left and right temporal lobe patients for either the side of focus or the effects of resection.

Verbal Memory

Adult Sample. Mean (SD) raw scores for pre-operative and post-operative verbal memory scores are shown in Figure 3 (Table 7 in Appendix H). The question of whether patients with left temporal lobe involvement could be differentiated from patients with right temporal lobe involvement on pre-operative measures of free recall (WMS Logical Memory: Immediate and Delayed; Paired Associates: Immediate and Delayed) and a measure of recognition memory (Recognition Memory: Words) was addressed by using ANOVA analyses. The only analyses which yielded significant effects were Paired Associates: Immediate (Group: $F(1,46) = 4.13, p < .05$) and RMT:Words (Group: $F(1,46) = 6.93, p < .01$), both of which showed that patients with a

right temporal lobe focus performed significantly better than patients with a left temporal lobe focus on pre-operative testing.

Insert Figure 3 about here

Repeated measures ANOVAs were used to compare the pre-operative scores with the post-operative scores (raw scores). The results of several analyses showed that the verbal memory scores for the left temporal lobe group decreased from the pre-operative assessment to the post-operative assessment while the scores for the right temporal lobe group remained relatively constant or even improved slightly from one testing session to the next. For Logical Memory: Immediate the main effect of Testing and the Group x Testing interaction were significant (Group: $F(1,46) = .51, p > .05$; Testing: $F(1,46) = 9.36, p < .01$; Group x Testing: $F(1,46) = 8.64, p < .01$). For Logical Memory: Delayed no significant effects were found (Group: $F(1,46) = 1.29, p > .05$; Testing: $F(1,46) = .06, p > .05$; Group x Testing: $F(1,46) = .45, p > .05$). For Paired Associates: Immediate the main effect of Group, Testing, and their interaction were all significant (Group: $F(1,46) = 13.67, p < .01$; Testing: $F(1,46) = 4.71, p < .04$; Group x Testing: $F(1,46) = 6.92, p < .01$). The main effects of Group, Testing, and their interaction were also all significant for Paired Associates: Delayed (Group: $F(1,46) = 12.76, p < .01$; Testing: $F(1,46) = 5.08, p < .03$; Group x Testing: $F(1,46) = 15.39, p < .01$). For Recognition Memory: Words only the main effects of Group and Testing were significant (Group: $F(1,46) = 13.22, p < .01$; Testing: $F(1,46) = 4.9, p < .01$; Group x Testing: $F(1,46) = 2.02, p > .05$). For this measure both groups of patients showed a decline in performance following temporal lobectomy.

Figure 3. Pre-Operative versus Post-Operative Verbal Memory Scores (Adult Sample)
When percent retention was calculated, as was possible with Logical Memory:

Immediate and Delayed (since both the immediate and delayed conditions of the test have the same requirements), performance for both left and right temporal groups remained relatively constant from the pre-operative assessment to the post-operative assessment (as shown in Figure 4 and Table 8 in Appendix H). However, the percent retained was marginally lower for the left temporal group pre-operatively (Group: $F(1,46) = 3.50, p < .07$; Testing: $F(1,46) = 1.02, p > .05$; Group x Testing: $F(1,46) = .13, p > .05$).

Insert Figure 4 about here

Child Sample. Mean (SD) age corrected standard z scores for pre-operative and post-operative sentence memory are shown in Figure 5 (Table 9 in Appendix H). The question of whether patients with left temporal lobe involvement could be differentiated from patients with right temporal lobe involvement on a pre-operative measure of free recall was addressed using an ANOVA analysis. Patients with a left temporal lobe focus performed better than patients with a right temporal lobe focus tested pre-operatively (Group: $F(1,24) = 7.45, p < .01$).

Insert Figure 5 about here

A repeated measures ANOVA was used to compare the pre-operative scores with the post-operative, age-corrected z scores. The results indicated that as the performance of the left temporal group decreased from the pre-operative assessment to the post-operative assessment the performance of the right temporal group

Figure 4. Percent Retained for Logical memory (Adult Sample)

Figure 5. Pre-Operative versus Post-Operative Verbal Memory Scores (Child Sample)

remained fairly constant. This relationship is reflected in a significant interaction (Group: $F(1,24) = 7.19$, $p < .01$; Testing: $F(1,24) = 4.02$, $p > .05$; Group x Testing: $F(1,24) = 6.84$, $p < .02$).

Summary. Of the six measures used to assess the acquisition and recall of verbal material for adults and children, the interaction of Group x Testing was significant in only four measures. The measures that showed significance included immediate memory for prose (Logical Memory for adults and Sentences for children) and immediate and delayed memory for pairs of words (adult group). For both groups, the immediate recall measures showed that patients who had undergone a left anterior temporal lobectomy showed a decline in performance from the pre-operative assessment to the post-operative assessment. When percent retention was analysed, as was possible for Logical Memory (for the adult sample) scores from both groups remained relatively constant from the pre-operative assessment to the post-operative assessment.

Spatial Memory

Adult Sample. Mean (SD) pre-operative and post-operative raw scores for the Rey-Osterrieth Figure are shown in Figure 6 (Table 10 in Appendix H). The question of whether patients with left temporal lobe involvement could be differentiated from patients with right temporal lobe involvement on a pre-operative measure of spatial memory was addressed using an ANOVA analysis. The constructional aspect of this task (copy phase) was performed well within normal limits for both temporal lobe groups. No significant effect for the Delayed Recall was observed.

Insert Figure 6 about here

Comparisons of the pre-operative with the post-operative raw scores indicated that performance improved slightly post-operatively for the left temporal group only on delay recall scores producing a significant main effect of Testing (Group: $F(1,46) = 3.21$, $p > .05$; Testing: $F(1,46) = 4.11$, $p < .05$; Group x Testing: $F(1,46) = 2.11$, $p > .05$). These findings were replicated when percent retention was calculated. Again the left temporal lobe group showed an improvement from the pre-operative assessment to the post-operative assessment, while the right temporal group remained relatively constant (see Figure 7 and Table 11 in Appendix H). The percent retained of the right temporal lobe group was, however, consistently lower than the percent retained of the right temporal lobe group (Group: $F(1,46) = 3.16$, $p > .05$; Testing: $F(1,46) = 5.34$, $p < .03$; Group x Testing: $F(1,46) = 1.88$, $p > .05$).

Insert Figure 7 about here

Child Sample. Mean (SD) age corrected z scores for pre-operative and post-operative performance on the Tactual Performance Test are shown in Figure 8 (Table 12 in Appendix H). Patients with left temporal lobe involvement performed similarly to those with right temporal lobe involvement. A repeated measures ANOVA showed a comparable improvement in performance occurred for both the left temporal lobe group and the right temporal lobe group from the pre-operative assessment to the post-operative assessment (Group: $F(1,24) = .25$, $p > .05$; Testing: $F(1,24) = 6.33$, $p < .02$; Group x Testing: $F(1,24) = .83$, $p > .05$).

Figure 6. Pre-Operative versus Post-Operative Spatial Memory (Adult Sample)

Figure 7. Percent Retained for Spatial Memory (Adult Sample)

Figure 8. Pre-Operative versus Post-Operative Spatial Memory Scores (Child Sample)

Figure 9. Pre-Operative versus Post-Operative Semantic Memory Scores (Adult Sample)

Figure 10. Pre-Operative versus Post-Operative Semantic Memory Scores (Child Sample)

Attention

Adult Sample. Mean (SD) scaled scores for pre-operative and post-operative Arithmetic and Digit Span subtests of the WAIS-R are shown in Figure 11 (Table 15 in Appendix H). Analyses of pre-operative measures showed a main effect for the Arithmetic subtest (Group: $F(1,46) = 4.27, p < .04$) but not for the Digit Span subtest. For the Arithmetic subtest patients with left temporal lobe involvement performed significantly better than patients with right temporal lobe.

 Insert Figure 11 about here

Repeated measures ANOVAs used to compare the pre-operative scores with the post-operative scaled scores showed a significant Group x Testing interaction for the Arithmetic subtest (Group: $F(1,46) = 1.75, p > .05$; Testing: $F(1,46) = .25, p > .05$; Group x Testing: $F(1,46) = 7.15, p < .01$) due to an improvement in performance post-operatively for the right temporal group while a decline in performance was noted for the left temporal lobe group. The results of the analysis for the Digit Span subtest showed that only the main effect of Testing was significant, with both groups improving post-operatively (Group: $F(1,46) = .19, p > .05$; Testing: $F(1,46) = 14.42, p < .01$; Group x Testing: $F(1,46) = .12, p > .05$).

Child Sample. Mean (SD) scaled scores for pre-operative and post-operative measures on the Arithmetic and Digit Span subtests of the WISC-R are shown in Figure 12 (Table 16 in Appendix H). The question of whether patients with left temporal lobe involvement could be differentiated from patients with right temporal lobe involvement on measures of attention tested pre-operatively was addressed using ANOVA analysis.

Figure 11. Pre-Operative versus Post-Operative Attention Scores (Adult Sample)

This measure did not show a main effect for Group for Arithmetic but did show a main effect of Group for Digit Span (Group: $F(1,24) = 6.42, p < .02$).

Insert Figure 12 about here

Repeated measures ANOVAs showed no significant effects for arithmetic (Group: $F(1,24) = .46, p > .05$; Testing: $F(1,24) = .47, p > .05$, Group x Testing: $F(1,24) = .14, p > .05$). For the Digit Span subtest, however, the main effects of Group and Testing were significant (Group: $F(1,24) = 6.84, p < .02$; Testing: $F(1,24) = 5.18, p < .03$; Group x Testing: $F(1,24) = .26, p < .62$). These effects were due a longer digit span for patients with left temporal involvement and a comparable pre-operative to post-operative decrease in performance in both groups.

Summary. The two measures used to assess attention yielded conflicting results. Performance on the Arithmetic subtest declined following resection for the adult left temporal lobe group, but improved on the Digit Span subtest following resection. The adult right temporal lobe group improved on both of these measures following resection. Both the left and right temporal lobe groups of children were relatively unaffected by the resection in terms of performance on the Arithmetic subtest, but the performance on the Digit Span subtest declined following resection for both the left and right temporal lobe groups in children.

Achievement

Adult Sample. Mean (SD) standard scores for pre-operative and post-operative achievement on the WRAT-R reading subtest are shown in Figure 13 (Table 17 in Appendix H). Patients with right and left temporal lobe involvement showed similar

Figure 12. Pre-Operative versus Post-Operative Attention Scores (Child Sample)

pre-operative performance. A repeated measures ANOVA compared the pre-operative with the post-operative standard scores. The results showed that the interaction of Group x Testing was significant (Group: $F(1,46) = .61, p > .05$; Testing: $F(1,46) = .63, p > .05$; Group x Testing: $F(1,46) = 7.52, p < .01$). This finding indicates that as performance for the left temporal group declined from the pre-operative assessment to the post-operative assessment performance for the right temporal lobe group remained fairly constant.

 Insert Figure 13 about here

Child Sample. Mean (SD) standard scores for pre-operative and post-operative achievement, as measured by the WRAT-R reading subtest, are shown in Figure 14 (Table 18 in Appendix H). No pre-operative differences occurred between the two groups. A second analysis using a repeated measures ANOVA failed to reveal any pre-post differences (Group: $F(1,24) = .63, p > .05$; Testing: $F(1,24) = .00, p > .05$; Group x Testing: $F(1,24) = 1.18, p > .05$).

 Insert Figure 14 about here

Summary. Achievement, as measured by the WRAT-R reading, declined following left temporal lobectomy for the adult sample, but not for the child sample.

Executive Functioning

Adult Sample. Mean (SD) raw scores for pre-operative and post-operative executive functioning (as measured by Oral Fluency and Wisconsin Card Sorting) are shown in Figure 15 (Table 19 in Appendix H). No pre-operative differences between

Figure 13. Pre-Operative versus Post-Operative Achievement Scores (Adult Sample)

Figure 14. Pre-Operative versus Post-Operative Achievement Scores (Child Sample)

right and left temporal lobe groups occurred for these tests.

Insert Figure 15 about here

A repeated measures ANOVA compared the pre-operative scores with the post-operative raw scores. Only the main effect of Testing was significant for Oral Fluency, due to an increase in performance post-operatively for both left and right temporal lobe groups (Group: $F(1,46) = .32, p > .05$; Testing: $F(1,46) = 7.26, p < .01$; Group x Testing: $F(1,46) = .05, p > .05$). There were no significant effects for the WCST (Group: $F(1,46) = .28, p > .05$; Testing: $F(1,46) = .14, p > .05$; Group x Testing: $F(1,46) = 4.2, p > .05$).

Child Sample. Mean (SD) age corrected z scores for pre-operative and post-operative measures of executive functioning (as measured by Oral Fluency and the Category Test) are shown in Figure 16 (Table 20 in Appendix H). Neither measure revealed a significant effect for pre-operative performance.

Insert Figure 16 about here

Repeated measures ANOVAs compared the pre-operative scores with the post-operative age corrected z scores. Only the main effect of Testing proved to be significant for the Category Test (Group: $F(1,24) = 1.28, p > .05$; Testing: $F(1,24) = 6.33, p < .02$; Group x Testing: $F(1,24) = .33, p > .05$). Neither main effects or the interaction proved to be significant for Oral Fluency (Group: $F(1,24) = 2.14, p > .05$; Testing: $F(1,24) = .38, p > .05$; Group x Testing: $F(1,24) = .17, p > .05$).

Summary. Executive functioning for both the adult sample and the child sample was unaffected by temporal lobectomy.

Figure 15. Pre-Operative versus Post-Operative Executive Functioning Scores (Adult Sample)

Figure 16. Pre-Operative versus Post-Operative Executive Functioning Scores (Child Sample)

Figure 17. Pre-Operative versus Post-Operative Perceptual Functioning Scores (Adult Sample)

Figure 18. Pre-Operative versus Post-Operative Perceptual Functioning Scores
continued (Adult Sample)

Testing: $F(1,24) = .02, p > .05$).

Insert Figure 19 about here

Summary. Perceptual functioning, as measured by the Picture Arrangement and Picture Completion subtests of the WAIS-R and WISC-R, was unaffected by temporal resection for both the adult sample and the child sample.

Tumour Sample

Since the number of patients with an etiology of tumour was small (left adult tumour sample, $n=3$; right adult tumour sample, $n=4$; left child tumour sample, $n=2$; and right child tumour sample, $n=5$) only descriptive statistics were compiled. Means and standard deviations for each measure are presented in Tables 23 to 39 in Appendix I.

Intelligence

Overall tumour patients generally show a similar pattern of performance to the entire sample. However, the tumour patients seem to begin at a higher overall level of functioning pre-operatively (an average of 8.3 points higher for adults and 12.2 points higher for children with left sided involvement and 9.6 points higher for adults and 11.5 points higher for children with right sided involvement).

Verbal Memory

The pattern of performance for the tumour groups of both the adult sample and the child sample generally mirrored the performance of the entire sample. With the exception of Paired Associate Immediate (right temporal lobe group) and Recognition Memory: Words (left temporal lobe group) where the tumour groups showed a slight

Figure 19. Pre-Operative versus Post-Operative Perceptual Functioning Scores (Child Sample)

increase in performance post-operatively, the performance of the entire sample showed a slight decline post-operatively. Again all scores, with the exception of Paired Associate and Recognition Memory: Words, were slightly higher for the tumour groups.

Means for percent retained for logical memory for the tumour sample showed the same pattern of results as findings for the entire sample, although again the tumour sample performed at a slightly higher level.

Spatial Memory

Similarly the tumour sample for the adult group reflected the same pattern of performance as the entire sample. Yet again the tumour sample scores were slightly higher than the scores for the entire sample. Performance for the tumour child group was exactly opposite to that seen with the entire sample. As the entire samples performance improved on the tactual performance test from the pre-operative assessment to the post-operative assessment the tumour groups performance declined from one assessment to the next.

Semantic Memory

Although the vocabulary means are higher for the tumour group than for the adult and child samples, the pattern of performance for all groups were similar.

Attention

Means for both Digit Span and Arithmetic for the adult tumour sample showed the same pattern of results as that observed for the entire adult sample, although again the adult tumour sample showed a slightly higher performance on both measures. The performance of the child tumour sample on these measures of attention declined slightly post-operatively (while the child sample as a whole showed some

slight improvement post-operatively), yet still remained superior to the performance of the entire child sample.

Achievement

The performance for both the tumour group and the entire sample reflected a similar pattern for both adults and children, with the means of the tumour sample were slightly higher both pre-operatively and post-operatively than the means for the entire sample.

Executive Functioning

For the adult sample the tumour patients improved slightly from the pre-operative assessment to the post-operative assessment on both measures of executive functioning. Means were comparable for both samples (tumour versus entire sample).

Perceptual Functioning

Means for both measures of perceptual functioning showed similar patterns of performance for both the tumour sample and the entire sample of adults and children. The exception being for the left temporal lobe child sample where the tumour group showed a slight decline in performance post-operatively while the entire child reflected a slight improvement post-operatively.

Summary. Overall the performance of the tumour patients mirrored the performance of the entire adult and child samples. Of interest is the finding that overall the tumour patients are performing at slightly higher levels of functioning than the entire samples of adults and children. Since the number of patients in the tumour groups are so small it is difficult to ascertain whether these differences are due to differences in duration or frequency. However, tumour patients are generally operated

on more quickly subsequent to diagnosis since as the size of the tumour increases, the frequency of seizures increases as so does the likelihood of complications.

Discussion

The most common form of epilepsy is that which originates in one or both temporal lobes. Of these, three-quarters of all patients experience their first seizure before reaching adulthood. One third of all temporal lobe seizure disorders can not be controlled medically, and are therefore defined as intractable. These three facts have encouraged neurosurgeons to operate on younger patients with surprisingly sparse neuropsychological outcome study data. With the advent of more sophisticated technology the surgical removal of the anterior temporal lobe is becoming a more common intervention for the relief of intractable seizures such that it is now imperative that the neuropsychological consequences of this intervention be documented, and that specific seizure history variables be identified should they significantly affect outcome.

The goal of this study was to examine pre-operative and post-operative memory functioning, within the context of a multiple memory system theory, in patients who have undergone unilateral temporal lobectomy for the relief of intractable complex partial seizures. As well, this study was carried out to examine the impact of specific seizure history variables including pre-operative level of cognitive functioning, gender, age of onset, side of focus, post-operative seizure control, and duration of the seizure disorder on memory performance following resection to determine their relative predictive value. The present study, and subsequent findings underline the importance of investigating subtle memory changes following temporal lobectomy as the findings may have ramifications on which group of patients may have the greatest benefit from this type of

surgery.

In order to discuss the implications of this study it is necessary to summarize the findings of this study (Table 40), and to determine whether these results support the hypotheses proposed in this study.

Insert Table 40 about here

As shown in this table, the findings of this study support the hypothesis that pre-operative global measures of intelligence were not sensitive to side of focus and were unchanged following resection of either the left temporal lobe or the right temporal lobe (although because of the small number of subjects differences may not have been able to be detected in this study). This finding supports the recent consensus in the literature (Chelune, Naugle, Lunders, Sedlak, & Awad, 1993; Jones-Gotman, Smith, & Zatorre, 1993; Phillips & McGlone, 1995) that while the Wechsler Intelligence scales are included in the majority of neuropsychological assessments they do not show reliable change following resection of either side, and therefore may not be as useful as previously thought. According to Hermann, Gold, Pusakulich, Wyler, Randolph, Rankin, and Hoy (1995) 92% of centres include the WAIS-R or the WISC-R in their pre-operative and post-operative assessment protocols. Yet study after study (this study included) have found that global measures of intelligence do not have significant lateralizing value or are these measures significantly affected by the resection itself (Ellenberg, Hirtz, & Nelson, 1986; Hermann et al., 1995; Phillips & McGlone, 1995; Smith & Milner, 1989). Based on these findings it may be time to re-evaluate the usefulness of the global measures of the Wechsler Intelligence scale in the post-operative

Table 40
Summary of Results

Measures of:	Difference Between Left vs Right Pre-operatively	Significant Interaction Pre-operative vs Post- operative
Intelligence (FSIQ)		
Adult	No	No
Child	No	No
Verbal Memory		
Adult		
Logical Memory		
Immediate	No	Yes (Lt ↓ ; Rt unchanged)
Delay	No	No
Paired Associates		
Immediate	Yes (Lt < Rt)	Yes (Lt ↓ ; Rt unchanged)
Delay	No	Yes (Lt ↓ ; Rt unchanged)
Recognition Memory		
Immediate	Yes (Lt < Rt)	Yes (Lt ↓ ; Rt unchanged)
Child		
Sentence Memory	Yes (Lt < Rt)	Yes (Lt ↓ ; Rt unchanged)
Spatial Memory		
Adult		
Rey-Osterrieth		
Delay	No	No
Child		
TPT	No	No (Both improved)
Semantic Memory (Vocabulary)		
Adult	No	No
Child	No	No (Both improved)
Attention		
Adult		
Digit Span	No	No
Arithmetic	Yes (Lt > Rt)	Yes (Lt unchanged; Rt ↑)
Child		
Digit Span	Yes (Lt > Rt)	No
Arithmetic	No	No
Achievement (WRAT-R)		
Adult	No	Yes (Lt ↓ ; Rt unchanged)
Child	No	No (Lt=Rt)

Executive Functioning

Adult

WCST	No	No
Oral Fluency	No	No

Child

Category Test	Yes (Lt > Rt)	No
Oral Fluency	No	No

Perceptual Functioning

Adult

Picture Arrangement	No	No
Picture Completion	No	No
Rey-Osterrieth: Copy	No	No

Child

Picture Arrangement	No	No
Picture Completion	No	No

neuropsychological surgical protocol. Perhaps the full test should be given pre-operatively only as a frame of reference, given the amount of time it takes to administer.

The results of the verbal memory tests were conflicting although generally did support hypothesis 2 which stated that verbal memory scores were expected to be lower for left temporal lobe patients than for right temporal lobe patients tested pre-operatively for both the adult and child samples. Two out of three tests for immediate verbal memory (Paired Associates: Immediate; RMT: Words and Sentence Memory) did confirm this hypothesis. However, Logical Memory: Immediate did not. The reason why prose recall (in the adult sample) may not be sensitive to the side of involvement while recall for word pairs, recognition of words, and recall of individual sentences may be sensitive to side of involvement may be explained by adopting a hypothesis proposed by Rausch (1985) where she postulated that verbal learning of words and unrelated sentences are at a "simplistic" or "rote" level (p. 258) and are thus dependent on the left hippocampus. On the other hand, Frisk and Milner (1990, p.133) suggest that verbal memory for prose "depends on the comprehension of syntactic-semantic information". In addition the passages promote images which suggest that verbal learning and recall of this type of material is dependent on both the left temporal and right temporal lobe structures. This hypothesis is further supported by the finding in the present study, as well in other recent work (Saling, Berkovic, O'Shea, Kalnins, Darby & Bladin, 1993), that performance on Logical Memory: Immediate and Delay is equally poor for both left temporal and right temporal lobe patients.

Furthermore, the results showed that the immediate scores of word pair recall,

word recognition and sentence recall were able to differentiate between left and right temporal lobe groups, but the delayed scores were not. This finding, while at first seemingly surprising, has been documented elsewhere. Giovagnoli, Casazza, and Avanzini (1995), in a study examining visual learning in patients with temporal lobe epilepsy, found that while performance on a selective reminding procedure could differentiate between left and right temporal lobe patients, performance on the delay trial of the task could not. These authors concluded that "the impairment in patients with right temporal lobe involvement may be limited to the learning stage, whereas the forgetting of learned material is similar to that of the left temporal lobe group" (p. 710). This conclusion was strengthened by the finding of no correlation between the immediate recall scores and the delay recall scores. Squire (1992) and Della Rocchetta, et al. (1995) all have concluded that the mesiotemporal structures are not necessary for delayed recall of verbal or spatial material. The findings of the present study corroborate these conclusions suggesting that the learning of material and memory storage (which is time-limited) are dependent on the hippocampus and adjacent regions.

The present study demonstrates that the tests used to assess spatial memory pre-operatively were not sensitive to side of involvement, thereby not providing support for hypothesis 3 which expected the right temporal lobe group to show a spatial memory deficit. The explanation of this finding could lie in the structure of the measures themselves in that both of these measures (Rey-Osterrieth Figure and the TPT), while chosen to assess spatial memory, may in fact not adequately test spatial memory because of a significant inherent verbal component. Milner (1975) argued that

a material specific memory decline is not evident after a right temporal lobe resection because measures which are traditionally used to assess spatial memory may have verbal components. If these measures do not adequately assess spatial memory then not finding a deficit in performance for the right temporal lobe group is not unexpected.

The findings of the present study generally support hypothesis 4 which stated that resection of the left temporal lobe would result in an exacerbation of the verbal memory deficits seen pre-operatively for adults and a similar pattern of deficit to that seen pre-operatively for children with left temporal lobe resection. In fact, five out of the six tests used to assess verbal memory in the present study showed a significant Group x Testing interaction with the left temporal lobe group consistently showing a decline in performance post-operatively in both the adult and child samples. Again, as with the pre-operative analyses, Logical Memory: Delay did not show a significant interaction. Both left and right temporal lobes groups performed very poorly post-operatively again suggesting that elements within the nature of the recall of prose passages is dependent on both left and right temporal lobe structures rendering both groups equally deficient. The finding of a significant Group x Testing interaction for Logical Memory: Immediate is not consistent with Rausch's hypothesis and is difficult to explain. Perhaps because Logical Memory: Immediate is still largely dependent on the left hippocampus and adjacent temporal structures, apart from relying to some degree on the right temporal lobe, that resection produces an even greater deficit than the poor performance seen with either left or right temporal lobe groups pre-operatively.

Although the findings of this study did not provide support for hypothesis 5, the findings can be explained by adopting Rausch's (1985) view that some tasks require or

employ both left and right temporal lobe structures for their execution. This view can be generalized to the two measures chosen in the present study to assess spatial memory in that they can both be shown to consist of at least a partial verbal memory component in addition to a spatial memory component thereby requiring both left and right temporal lobe structures for their recall. A resection of the right temporal lobe would therefore not result in a marked deficit post-operatively which is what the present study confirms. Moreover, a slight improvement in both scores was noted post-operatively perhaps due to the change in the learning paradigm. That is, incidental learning pre-operatively to intentional learning post-operatively. Traditionally, and as was the case in this study, the Rey-Osterrieth Figure and the Tactual Performance Tests both use an incidental learning paradigm. However, when testing post-operatively the patient has some indication that they will be asked to later recall the material presented to them (based on previous experience). Thus during the post-operative copy presentation the patient may use a different strategy to encode the information (using as much verbal memory as possible by mumbling "there's a cross on the side and at the bottom.....") knowing that they will later have to reproduce the figure, hence scores tend to improve post-operatively (Tombaugh et al., 1992).

The results of the pre-operative and post-operative analyses of semantic memory, attention, achievement, executive functioning and perceptual functioning are in general agreement with hypothesis 6 which stated that these measures were expected to be within normal range for both left temporal and right temporal lobe groups for both the adult and child samples, pre-operatively and post-operatively. Although some interactions of Group x Testing were noted in the adult sample on these

measures (specifically on measures of attention and achievement) all scores are within normal limits. Hermann et al. (1995) observed that a left temporal lobe resected group scored lower on the Vocabulary subtest of the WAIS-R, but the difference although statistically significant amounted to only 1 scaled point difference. These significant interactions may also reflect changes in AED medication post-operatively where the left temporal lobe resection seems to be the most vulnerable to the effects of AEDs. Studies have documented the impairment of attention after only 1 month on two of the first-line antiepileptic medications (Carbamazepine and Phenytoin) (Forsythe, Butler, Berg, & McGuire, 1991; Trimble, 1987).

Material Specific Memory Hypotheses Within The Model of Multiple Memory Systems

The results of the present study demonstrate unequivocally that memory per se, is not a single unity. In fact, even immediate verbal recall and delay verbal recall seem to involve different anatomical structures, thereby suggesting the existence of multiple memory systems.

The currently accepted model of memory functioning has adopted the material specific model which supports the view that the left and right hemispheres, specifically the medial temporal region of those hemispheres, are specialized for the learning, encoding, retention, and retrieval of verbal and spatial material, respectively. Squire (1992) proposed that it is the hippocampus and surrounding cortex of the medial temporal lobe (entorhinal cortex, perirhinal cortex, and parahippocampal cortex) which are essential for declarative memory (also referred to as explicit memory or relational memory in the literature) by way of its reciprocal projections with many other

areas of the neocortex including other areas of the temporal lobe, frontal lobe, and parietal lobe. This proposal advances the view of multiple memory systems where each memory system is anatomically distinct, and furthermore that each of these memory systems is unique in their acquisition and storage of information. This proposal gains support from the animal studies of monkeys and rats (Zola-Morgan, Squire & Amaral, 1989) which show that specifically the hippocampus is essential to declarative memory as damage to surrounding areas, such as the fornix or mamillary bodies, had only a mild effect on memory.

The results of the pre-operative versus post-operative comparisons for verbal "rote" immediate memory in the current study showed that the left anterior temporal lobectomy group (adults and children) showed the expected decline in declarative memory thereby supporting Squire's proposal that declarative memory is dependent on the hippocampal memory system.

Why the present study and others in the literature have found that right temporal lobectomy (in adults) does not show a decline in specific episodic memory following surgery remains unclear. Several explanations are possible. First, it could be argued that the instructions for the verbal memory tasks were different in that recall was assessed immediately and then following a delay while there was only the delay condition for the spatial memory tasks. This difference in instruction may have altered the strategy used to learn the material. In immediate recall the storage of information may not have had time to project to other areas thereby remaining fully dependent on the hippocampal memory system. The spatial memory tasks, on the other hand, allowed "time" for the learned material to project elsewhere in the cortex as recall was

assessed after a time delay. Second, the nature of the spatial tasks allowed the presence of a familiar component to become present. That is, when the patient was redrawing the figure or object from memory he/she was simultaneously assessing whether the presence of that segment of the drawing or the object was familiar. Recognition memory, although usually thought of as a traditional assessment of memory and usually expressed as a form of declarative memory, may also depend on the unconscious process of familiarity making recognition memory part of the nondeclarative memory system. Phillip, Malamut, Bachevalier, and Mishkin (1988) concluded from an ablation study of monkeys that visual recognition memory is dependent on the inferotemporal neocortex. If the view is adopted that the spatial memory tasks used in this study may have incorporated a familiarity component, then the findings of this study are not unexpected and remain consistent with the multiple memory system proposal.

The Effect of Resection on Other Areas of Cognitive Functioning within the Framework of the Multiple Memory Hypothesis

The hippocampal memory system is essential to newly learned material, and is only a temporary storage site of that material. This is consistent with the view that semantic memory (knowledge of facts) which depends on long term memory is not dependent on the hippocampal formation, and therefore should not be affected by temporal resection. Some other studies (Langfitt & Rausch, 1996; Wilkins & Moscovitch, 1978) have observed a deficit in naming (which is also classified as semantic memory) following left temporal lobe resection, although documentation of this finding is inconsistent. These findings support the hypothesis that there are at least two systems

of semantic memory, lending further support to the multiple memory systems model.

Likewise attention, executive functioning and perceptual functioning are not dependent on either the left or right hippocampal formation, and therefore should not and were not affected by temporal resection. A slight improvement in scores may reflect a change in AED medication from the pre-operative assessment to the post-operative assessment. The unexpected finding in this study of a deterioration of functioning in a measure of achievement following left temporal resection has not been previously reported in the literature.

Several other issues have surfaced in this study and need to be addressed. This study, as with any study that has a repeated measures component, is subject to concern regarding the issue of practise effects. Improved post-operative performance may be classified as a simple practice effect. However, with a relatively long period of time between the pre-operative assessment and the post-operative assessment (an average of 13.9 months in this study, with a range of 2 months to 30 months), practice effects probably didn't make much of a contribution to the overall improvement observed post-operatively and would be more probable as a consequence of a change in AED medication.

A second issue revolves around the idea of prediction. While the findings of this study are largely consistent with previous studies in the literature, one should be reminded that in this study, as with the majority of studies, statistical analyses were done for a group. That is, data were averaged together and thereby reflect only the most common patterns. How an individual patient may function cognitively after this type of resection is difficult to predict as individual variability plays a key role. Bearing

this in mind, however, the results of this study and of recent studies in the literature offer no support for the position of delaying surgery because of a risk of overall cognitive decline.

Variables that may be Helpful in Predicting Cognitive Outcome

Comparisons of pre-operative versus post-operative performance on measures of verbal memory and spatial memory in the literature generally reflect an effect of age (that is, those in the younger samples showed the greatest improvement post-operatively). Loring (1993) observed that patients above 35 years of age showed the greatest amount of material specific memory decline following left temporal lobe resection. However, in the present study the small number of subjects relative to the number of independent variables did not allow regression analyses to be carried out.

Tumour patients (both right and left temporal lobe groups) generally showed a similar pattern of performance for verbal and spatial memory when compared with the entire sample of adults and children with the exception that the tumour patients performed at a higher level of cognitive functioning. Tumour patients are generally operated on relatively quickly thereby reducing the duration of illness (in the present study tumour patients, combining both adults and children, had a duration of illness averaging 10.1 years versus 16.4 years for the nontumour group) as well as a shorter period of antiepileptic medication use both of which may have an impact on cognitive functioning.

Summary

The findings of this study have paved the way for further research involving children in that this was the first study to document outcome post-resection in a detailed

manner over many areas of cognitive functioning. The results of this study, for both adults and children, support the multiple memory system model in that memory is not a single entity but seems to consist of multiple systems each dependent on separate anatomical systems. Underlying this model is the principle that memory per se is dissociated from other intellectual functions. Furthermore, seizure history variables such as duration can be a useful predictor variable in predicting outcome to a limited degree (for verbal memory functioning post-operatively in children).

There are several main points that have been made in this dissertation which could direct the employment of a revised pre-operative and post-operative assessment protocol for surgical candidates for intractable epilepsy. The findings of the current study lends support for the growing body of literature which is questioning the usefulness of global measures of intelligence. Therefore the first revision to the existing protocol would be the removal of the WAIS-R/WISC-R from the post-operative assessment. Second, a more diverse and comprehensive battery of immediate "rote" recall of verbal and spatial memory tests should be added to the assessment. Third, measures of semantic memory, attention, achievement, executive functioning and perceptual functioning can also be removed from the protocol. Future research, based on the findings of this study would be prospective in nature, include a more elaborate set of measures used to assess both verbal and spatial memory and revisit the issue of prediction of post-resection cognitive functioning based on a larger number of subjects.

Limitations

This study is limited with respect to generalization in that there may have been an inadvertent subject selection bias. Patients from University Hospital were generally

the more severe cases drawn from an international population, while the patients from Children's Hospital of Eastern Ontario were more straightforward from a medical standpoint and drawn from a local population.

Also, since the alpha level was set at .05 and a large number of comparisons were made (the conceptual nature of the analyses drove the pre-operative comparisons and the pre-operative versus post-operative comparisons) the error rate may have been inflated. Some of the statistically significant findings of this study may have been spurious and therefore should be replicated.

REFERENCES

- Abony-Bencze, K., & McGlone, J. (1988). Do pre-operative neuropsychological scores predict performance on the intracarotid sodium amobarbital protocol? Poster session presented at the annual meeting of the Canadian Psychological Association, Montreal, Quebec.
- Aggleton, J.P., & Shaw, C. (1996). Amnesia and recognition memory: A re-analysis of psychometric data. Neuropsychologia, 34(1), 51-62.
- Aikia, M., Kalviainen, R., Sivenius, J., Halonen, T., & Riekkinen, P.J. (1992). Cognitive effects of carbamazepine and phenytoin monotherapy in newly diagnosed epilepsy: one year follow-up. Epilepsy Research, 11(3), 199-203.
- Alvarez, P., & Squire, L.R. (1994). Memory consolidation and the medial temporal lobe: A simple network model. Proceedings of the National Academy of Science, 91, 7041-7045.
- Aman, M.G., Werry, J.S., Paxton, J.W., Turbott, S.H., & Stewart, A.W. (1990). Effects of carbamazepine on psychomotor performance in children as a function of drug concentration, seizure type and time of medication. Epilepsia, 31(1), 51-60.
- Andermann, F. (1977). Selection and investigation of candidates for surgical treatment of temporal lobe epilepsy in childhood and adolescence in. Blaw, M.E., Rapin, I and Kinsbourne, M. (Eds.) Topics in Child Neurology. New York: Spectrum Press.
- Annegers, J.F. (1992). Methodological issues in outcome assessment. In; Theodore, W.H. (Ed.), Treatment of Epilepsy. Chapter 28. New York: Elsevier Science Publishers.
- Bancaud, J. & Henriksen, O. (1981). Proposal for revised clinical and electroencephalographic classification of epileptic seizures. Epilepsia, 22, 489-501.

- Baumann, R.J., Marx, M.B., & Leonidakas, M.G. (1978). Epilepsy in rural Kentucky: Prevalence in a population of school age children. Epilepsia, 19, 75-80.
- Bennett, T.L., & Krein, L.K. (1989). The neuropsychological impact of epilepsy: Psychological and social impact. In Reynolds, C.R., & Fletcher-Janzen, E (eds). The Handbook of Clinical Child Neuropsychology, 419-442. Plenum Press, New York.
- Benton, A.L. (1968). Differential behavioural effects in frontal lobe disease. Neuropsychology, 6, 53-60.
- Benton, A.L. (1962). Behavioural indices of brain injury in school children. Child Development, 33, 199-208.
- Beran, R.G., Hall, L., & Michelazzi, J. (1985). An accurate assessment of the prevalence ratio of epilepsy adequately adjusted for influencing factors. Neuroepidemiology, 4, 71-81.
- Berg, E.A. (1948). A simple objective technique for measuring flexibility in thinking. Journal of General Psychology, 39, 15-22.
- Bergin, P.S., Baxendale, S.A., Thompson, P.J., & Fish, D.R. (1993). Remote memory in epilepsy. Abstract from the Annual Meeting of the American Epilepsy Society. Neuropsychologia, 34(6).
- Blakemore, C.B. & Falconer, M.A. (1967). Long term effects of anterior temporal lobectomy on certain cognitive functions. Journal of Neurology, Neurosurgery and Psychiatry, 30, 364-367.
- Blennow, G., Heijbel, J., Sandstedt, P., & Tonnby, B. (1990). Discontinuation of antiepileptic drugs in children who have outgrown epilepsy: effects on cognitive function. Epilepsia, 31 supplement 4, s50-s53.

- Blume, W.T., & Kaibara, M. (1991). Localization of epileptic foci in children. Canadian Journal of Neurological Sciences, 18, 570-572.
- Bodensteiner, J.B., Brownsworth, R.D. & Knapik, J.R. (1988). Interobserver variability in the ILAE classification of seizures in childhood. Epilepsia, 29, 123-128.
- Bridgmen, P.A., Malamut, B.L., Sperling, M.R., Saykin, A.J., & O'Connor, M.J. (1989). Memory during subclinical hippocampal seizures. Neurology, 39, 853-856.
- Bright, R. (1831). Reports of medical cases selected with a view of illustrating the symptoms and cure of diseases by a reference to morbid anatomy. Diseases of the Brain and Nervous System, vol.2.
- Brockway, J.P., Follmer, R.L., Greenhoot, J.H., & Follmer, L. (1993). Highly specific memory deficits accompany temporal lobe epilepsy. Abstract from the Annual Meeting of the American Epilepsy Society. Neuropsychologia, 34(6).
- Bruni, J. (1987). Clinical management of epilepsy in children. Drug Protocol, 2(1), 46-53.
- Camfield, P.R., Gates, R., Ronen, G., Camfield, C., Ferguson, A., & MacDonald, G.W. (1984). Comparison of cognitive ability, personality profile and school success in epileptic children with pure right versus left temporal lobe EEG foci. Annals of Neurology, 15(2), 122-126.
- Cavazzuti, V., Winston, K., & Baker, R. (1980). Psychological changes following surgery for tumours in the temporal lobe. Journal of Neurosurgery, 53, 618-626.
- Channon, S. & Polkey, C.E. (1990). Memory and temporal lobe surgery: A review. Journal of the Royal Society of Medicine, 83, 100-103.
- Chelune, G.J., Naugle, R.I., Luders, H., & Awad, I.A. (1991). Prediction of cognitive change as a function of preoperative ability status among temporal lobectomy patients

- seen at 6-month follow-up. Neurology, 41, 399-404.
- Cohen, N.J. & Eichenbaum, H. (1993). Memory, Amnesia and the Hippocampal System. Cambridge: The MIT Press.
- Cohen, M. (1992). Auditory/verbal and visual/spatial memory in children with complex partial epilepsy of temporal lobe origin. Brain and Cognition, 20, 315-326.
- Cowan, L.D., Bodensteiner, J.B., Leviton, A & Doherty, L. (1989). Prevalence of the epilepsies in children and adolescents. Epilepsia, 30, 94-106.
- Cramer, J.A., Mattson, R.H., Prevey, M.L., Scheyer, R.D., & Ouellette, V.L. (1989). How often is medication taken as prescribed? Journal of the American Medical Association, 261, 3273-3277.
- Davidson, S., & Falconer, M.A. (1975). Outcome of surgery in 40 children with temporal lobe epilepsy. Lancet, 1, 1260-1263.
- Delaney, R.C., Rosen, A.J., Mattson, R.H. & Novelly, R.A. (1980). Memory function in focal epilepsy: A comparison of nonsurgical, unilateral temporal lobe and frontal lobe samples. Cortex, 16, 103-117.
- Della-Rocchetta, A.I., Gadian, D.G., Connelly, A., Polkey, C.E., Jackson, G.D., Watkins, K.E., Johnson, C.L., Mishkin, M., & Vargha-Khadem, F. (1995). Verbal memory impairment after right temporal lobe surgery: Role of contralateral damage as revealed by H magnetic resonance spectroscopy and T relaxometry. Neurology, 45, 797-802.
- Dennis, M., Farrell, K., Hoffman, H.J., Hendrick, E.B., Becker, L.E., & Murphy, E.G. (1988). Recognition memory of item, associative and serial-order information after temporal lobectomy for seizure disorder. Neuropsychologia, 26(1), 53-65.
- Dikman, S., & Matthews, C.G. (1977). Effect of major motor seizure frequency upon

- cognitive-intellectual functions in adults. Epilepsia, 18, 21-36.
- Dikman, S, Matthews, C.G., & Harley, J.P. (1975). The effect of early versus late onset of major motor epilepsy upon cognitive-intellectual performance. Epilepsia, 16, 73-81.
- Dodrill, C.B. (1988). Neuropsychology. In J. Laidlaw, A. Richens, & J. Oxley (Eds.), A Textbook of Epilepsy. London: Churchill Livingstone.
- Dodrill, C.B. (1992a). Problems in the assessment of cognitive effects of antiepileptic drugs. Epilepsia, 33(Suppl 6), 29-32.
- Dodrill, C.B. (1992b). Interictal cognitive aspects of epilepsy. Epilepsia, 33(Supp. 6), S7-S10.
- Dodrill, C.B.D., & Wilensky, A.J. (1992). Neuropsychological abilities before and after 5 years of stable antiepileptic drug therapy. Epilepsia, 33(2), 327-334.
- Dreifuss, F.E. (1992). Present status in the treatment of the epilepsies. In Theodore, W.H. (Ed.), Surgical Treatment of Epilepsy (Epilepsy Research Supplement 5). New York: Elsevier Science Publishers.
- Durwen, H.F. (1993). Right temporal lobe epilepsy and nonverbal memory impairment. Epilepsia, 34(6), 79.
- Ellenberg, S., Hirtz, D.G., & Nelson, K.B. (1986). Do seizures cause intellectual deterioration? New England Journal of Medicine, 314, 1085-1088.
- Engel, J. (1987). Outcome with respect to epileptic seizures In Theodore, W.H. (Ed.), Surgical Treatment of the Epilepsies. 553-571. New York: Elsevier Science Publishers.
- Engel, J. (1989). Seizures and Epilepsy. Philadelphia: Davis Company.
- Epilepsy Canada, Health Statistics Report (1994).

- Falconer, M.A. (1970). Significance of surgery for temporal lobe epilepsy in children and adolescence. Journal of Neurosurgery, 33, 233-252.
- Farwell, J.R., Dodrill, C.B, & Batzel, L.W. (1985). Neuropsychological abilities of children with epilepsy. Epilepsia, 26(5), 395-400.
- Feindel, W., & Rasmussen, T. (1991). Temporal lobectomy with amygdalectomy and minimal hippocampal resection: Review of 100 cases. Canadian Journal of Neurological Sciences, 18, 603-605.
- Ferguson, G.A. (1976). Statistical Analysis in Psychology and Education. New York: McGraw-Hill.
- Forsythe, I., Butler, R., Berg, I., & McGuire, R. (1991). Cognitive impairment in new cases of epilepsy randomly assigned to carbamazepine, phenytoin and sodium valporate. Developmental Medicine in Child Neurology, 33(6), 524-534.
- Frisk, V., & Milner, B. (1990). The relationship of working memory to the immediate recall of stories following unilateral temporal or frontal lobectomy. Neuropsychologia, 28(2), 121-135.
- Gallassi, R., Morreale, A., Di Sarro, R., Lugaresi, E & Baruzzi, A. (1992). Cognitive effects of antiepileptic drug discontinuation. Epilepsia, 33 (Suppl. 6), S41-S44.
- Gillham, R.A., Williams, N., Wiedmann, K.D., & Butler, E. (1990). Cognitive function in adult epileptic patients established on anticonvulsant monotherapy. Epilepsy Research, 7(3), 219-225.
- Gilliam, D., Fletcher, J., & Levin, H. (1986, February). Development of verbal, nonverbal and recognition memory in children. Paper presented at the annual meeting of the International Neuropsychological Society Meeting, Denver, Colorado.

- Giovagnoli, A.R., Casazza, M., & Aranzini, G. (1995). Visual learning on a selective reminding procedure and delayed recall in patients with temporal lobe epilepsy. Epilepsia, 36(7), 704-711.
- Girvin, J.P. (1991). Surgery for epilepsy: A new focus. Canadian Medical Association Journal, 144(2), 147.
- Girvin, J.P., McGlone, J., McLachlan, R.S., & Blume, W.T. (1987). Validity on the sodium amobarbital test for memory in selected patients. [Abstract]. Epilepsia, 28, 636.
- Goldstein, R., Duchowny, M., Jayakar, P., Resnick, T.J., & Altman, N. (1993). Predictors of seizure relief after temporal lobectomy in children. Abstract from the annual meeting of the American Epilepsy Society. Neuropsychologia, 34(6).
- Green, J.R., & Pootrakul, A. (1982). Surgical aspects of the treatment of epilepsy during childhood and adolescence. Arizona Medicine, 39, 35-38.
- Greene, R.L. (1992). Human Memory Paradigms and Paradoxes. Erlbaum Publishers: New York.
- Haerer, A.F., Anderson, D.W., & Schoenberg, B.S. (1986). Prevalence and clinical features of epilepsy in a biracial United States population. Epilepsia, 27, 66-75.
- Halstead, W.C. (1947). Brain and Intelligence. Chicago: University of Chicago Press.
- Hauser, W.A., & Hesdorffer, D.C. (1990). Epilepsy: Frequency, Causes and Consequences. Demos Publications: New York.
- Hermann, B.P., Gold, J., Pusakulich, R., Wyler, A.R., Randolph, C., Rankin, G. & Hoy, W. (1995). Wechsler Adult Intelligence Scale-Revised in the evaluation of anterior temporal lobectomy candidates. Epilepsia, 36(5), 480-487.
- Hermann, B.P., Seidenberg, M., Haltiner, A., & Wyler, A.R. (1995). Relationship of age of

- onset, chronologic age and adequacy of preoperative performance to verbal memory change after anterior temporal lobectomy. Epilepsia, 36(2), 137-145.
- Hermann, B., Pusakalich, R., Gold, J., Rankin, G., & Wyler, A. (1993). Utility of the WAIS-R in evaluation of anterior temporal lobectomy candidates. Abstract from the annual meeting of the American Epilepsy Society. Neuropsychologia, 34(6).
- Hermann, B.P., Wyler, A.R., Somes, G., Berry, A.D., & Dohan, F.C. (1992). Pathological status of the mesial temporal lobe predicts memory outcome from left anterior temporal lobectomy. Neurosurgery, 31(4), 652-657.
- Hermann, B.P., & Wyler, A.R. (1988). Neuropsychological outcome of anterior temporal lobectomy. Journal of Epilepsy, 1, 35-45.
- Hollingsworth, J.S. (1978). Mental retardation, cerebral palsy and epilepsy in Alabama: A sociological analysis. Alabama, The University of Alabama Press.
- Ivnik, R.J., Malec, J.F., Sharbrough, F.W., Cascino, G.D., Hirschorn, K.A., Crook, T.H., & Larrabee, G.J. (1993). Traditional and computerized assessment procedures applied to the evaluation of memory change after temporal lobectomy. Archives of Clinical Neuropsychology, 8, 69-81.
- Jacoby, L.L. (1983). Perceptual enhancement: Persistent effects of an experience. Journal of Experimental Psychology-Learning, Memory, and Cognition, 9(1), 21-38.
- Jambaque, I., Dellatolas, G., Dulac, O., Ponsot, G., & Signoret, J.L. (1993). Verbal and visual memory impairment in children with epilepsy. Neuropsychologia, 31 (12), 1321-1337.
- Jastak, S., & Wilkinson, G.(1984). The Wide Range Achievement Test-Revised. Jastak Associates Inc: Wilmington, Delaware.

- Jensen, I. (1976). Temporal lobe epilepsy. Acta Neurology of Scandinavia, 53, 103-118.
- Jones-Gotman, M., Smith, M.L., & Zatorre R.J. (1993). Neuropsychological testing for localizing and lateralizing the epileptogenic region. In J. Engel (Ed) Surgical Treatment of the Epilepsies. New York: Raven Press.
- Kaufman, A.S. (1979). Intelligent Testing the WISC-R. New York: John Wiley.
- Kesner, R.P. (1980). An attribute analysis of memory: The role of the hippocampus. Physiological Psychology, 8(2), 189-197.
- Kimura, D. (1963). Right temporal lobe damage. Archives of Neurology, 8, 264-271.
- Kimura, D. (1984). Neuropsychology Test Procedures. University Hospital, London, Ontario.
- Kline, N.F., Fraser, R., & Labar, D. (1993). Variables affecting employment outcome after epilepsy surgery. Abstract from the annual meeting of the American Epilepsy Society. Neuropsychologia, 34(6).
- Knights, R.K. & Norwood, J.A. (1977): A Neuropsychological Test Battery For Children: Examiner's Manual. Ottawa: Robert M. Knights Psychological Consultants Inc.
- Knights, R.M., & Norwood, J.A. (1980). Revised Smoothed Normative Data on the Neuropsychological Test Battery for Children.
- Kolb, B & Whishaw, I.Q. (1990). Fundamentals of Human Neuropsychology. New York: Freeman and Company.
- Kotagal, P., Rothner, A.D., & Erenberg, G. (1987). Complex partial seizures of childhood onset: A five year follow-up study. Archives of Neurology, 44, 1177-1180.
- Kuehn, S.M., & Snow, W.G. (1992). Are the Rey and Taylor figures equivalent? Archives of Clinical Neuropsychology, 7, 445-448.
- Ladavas, E., Umiltà, C., & Provinciali, L. (1979). Hemisphere-dependent cognitive

- performances in epileptic patients. Epilepsia, 20, 493-502.
- Langfitt, J.T., & Rausch, R. (1996). Word finding deficits persist after left anterotemporal lobectomy. Archives of Neurology, 53, 72-76.
- Larrabee, G.E., Kane, R.L., Schuck, J.K., & Francis, D.L. (1985). Construct validity of various memory testing procedures. Journal of Clinical and Experimental Neuropsychology, 7, 239-250.
- Lashley, K.S. (1929). Brain mechanisms and intelligence: A quantitative study of injuries to the brain. Chicago:Univeristy of Chicago Press.
- Lee, G.P., Loring, D.W., & Thompson, J.L. (1989). Construct validity of material-specific memory measures following unilateral temporal lobe ablations. Psychological Assessment, 1(3), 192-197.
- Leonard, G. (1991). Temporal lobe surgery for epilepsy: Neuropsychological variables related to surgical outcome. Canadian Journal of Neurological Sciences, 18, 593-597.
- Leppik, I.E. (1992). Intractable epilepsy in adults. In: Theodore, W.H. (Ed.), Surgical treatment of epilepsy. New York: Elsevier Science Publishers.
- Lesser, R.P., Fisher, R.S., & Uematsu, S. (1992). Assessment of surgical outcome. In; Theodore, W.H. (Ed.), Surgical treatment of epilepsy. Chapter 27. New York: Elsevier Science Publishers.
- Lesser, R.P., Lunders, H., & Wyllie, E. (1986). Mental deterioration in epilepsy. Epilepsia, 27(2 supp), 105-123.
- Lezak, M.D. (1983). Neuropsychological assessment. New York: Oxford University Press.
- Lezak, M.D. (1995). Neuropsychological assessment. New York: Oxford University Press

- Lieb, J.P., Rausch, R., Engel, J., Brown, W.J., & Crandall, P.H. (1982). Changes in Intelligence following temporal lobectomy: Relationship to EEG activity, seizure relief and pathology. Epilepsia, 23, 1-13.
- Loiseau, P., Strube, E., & Signoret, J.L. (1987). Memory and epilepsy. In Trimble, M. (Ed) Epilepsy, behaviour and cognitive function. New York: Wiley Publishers.
- Loring, D.W., Meador, K.J., & Lee, G.P. (1994). Effects of temporal lobectomy on generative fluency and other language functions. Archives of Clinical Neuropsychology, 9(3), 229-238.
- Loring, D.W., Meador, K.J., Lee, G.P., Nichols, M.E., King, D.W., Gallagher, B.B., Murro, A.M. & Smith, J.R. (1994). Wada memory performance predicts seizure outcome following anterior temporal lobectomy. Neurology, 44, 2322-2324.
- Loring, D.W. (1993). Wada memory testing and hippocampal volume measurements in the evaluation for temporal lobectomy. Neurology, 43, 1780-1793.
- Macartney-Filgate, M.S., & Vriezen, E.R. (1988). Intercorrelation of clinical tests of verbal memory. Archives of Clinical Neuropsychology, 3, 121-126.
- Macdonald, R.L., & Meldrum, B.S. (1989). Principles of antiepileptic drug action. In: Levy, R., Mattson, R., Meldrum, J.K., & Dreifuss, F.E. (Eds.), Antiepileptic Drugs. Raven Press, New York. 59-83.
- Matarazzo, R.G., & Matarazzo, J.D. (1984). Assessment of adult intelligence in clinical practise In Mc Reynolds, P. & Chelune, G.J. (Eds.), Advances in Psychological Assessment, 6, 77-108.
- Mateer, C.A., & Dodrill, C., (1985). Atypical language dominance. Poster session presented at the annual meeting of the International Neuropsychological Society, San Diego,

California.

- Matthews, C.G., (1992). The neuropsychology of epilepsy: An overview. Journal of Clinical and Experimental Neuropsychology, 14(1), 133-143.
- Mattson, R.H. (1992). Drug treatment of uncontrolled seizures. In: Theodore, W.H. (Ed.), Surgical treatment of epilepsy. New York: Elsevier Science Publishers.
- May, T.W., Bulmahn, A., Wohlhuter, M., & Rambeck, B. (1992). Effects of withdrawal of phenytoin on cognitive and psychomotor functions in hospitalized epileptic patients on polytherapy. Acta Neurology Scandinavica, 86(2), 165-170.
- McCarthy, R.A., & Warrington, E. (1990). Cognitive neuropsychology: A clinical introduction. Academic Press, London.
- McGlone, J. (1985). Symposium on the sodium amytal procedure. Paper presented at the annual meeting of the International Neuropsychological Society, San Diego, California.
- McGlone, J. (1992). Sex differences in WAIS-R verbal minus performance IQ discrepancy scores after temporal lobectomy. [Abstract] Journal of Clinical and Experimental Neuropsychology, 14(1), 97.
- McGlone, J. (1994). Memory complaints before and after temporal lobectomy: Do they predict memory performance or lesion laterality? Epilepsia, 35 (3), 529-539.
- McGlone, J., & Wands, B. (1991). Self-report of memory function in patients with temporal lobe epilepsy and temporal lobectomy. Cortex, 27, 19-28.
- Meador, K.J., Loring, D.W., Huh, K., Gallagher, B.B., & King, D.W. (1990). Comparative cognitive effects of anticonvulsants. Neurology, 40(3 pt 1), 391-394.
- Meyer, F.B., Marsh, W.R., Laws, E.R. & Sharbrough, F.W. (1986). Temporal lobectomy in

- children with epilepsy. Journal of Neurosurgery, 64, 371-376.
- Milner, B. (1958). Psychological defects produced by temporal lobe excisions. Research Publication for the Association of Research for Nervous and Mental Disorders, 36, 244.
- Milner, B. (1975). Psychological aspects of epilepsy and its neurosurgical management. In Advances in Neurology, Vol 8., New York.
- Mizrahi, E.M., Kellaway, P., Grossman, R.G., Rutecki, P.A., Armstrong, D., Rettig, G., & Loewen, S. (1990). Anterior temporal lobectomy and medically refractory temporal lobe epilepsy of childhood. Epilepsia, 31(3), 302-312.
- Naugle, R.I., Chelune, G.J., Cheek, R., Luders, H., & Awad, I.A. (1993). Detection of changes in material-specific memory following temporal lobectomy using the Wechsler memory scale-revised. Archives of Clinical Neuropsychology, 8, 381-395.
- Novelly, R., Augustine, E., Mattson, R., Glaser, G., Williamson, P., Spencer, D., & Spencer, S. (1984). Selective memory improvement and impairment in temporal lobectomy for epilepsy. Annals of Neurology, 15, 64-67.
- Oakes, W.J., Swartzwelder, H.S., Santos, C.C., & Thompson, R.J. (1993). Psychosocial and medical outcomes of temporal lobectomy for temporal lobe epilepsy. Abstract from the Annual Meeting of the American Epilepsy Society. Neuropsychologia, 34(6).
- Ossetin, J. (1988). Methods and problems in the assessment of cognitive function in epileptic patients. In Trimble, M.R., & Reynolds, E.H. (Eds.), Epilepsy, behaviour and cognitive function, 9-26, England.
- Ojemann, G.A., & Dodrill, C.B. (1985). Verbal memory deficits after left temporal lobectomy for epilepsy. Journal of Neurosurgery, 62, 101-107.

- O'Learly, D.S., Seidenberg, M., Berent, S., & Boll, T.J. (1981). Effects of age of onset of tonic-clonic seizures on neuropsychological performance in children. Epilepsia, 22, 197-204.
- Osterrieth, P.A. (1944). Le test de copie d'une figure complexe: Contribution à l'étude de la perception et de la mémoire. Archives de Psychologie, 30, 286-356.
- Parkin, A.J. & Lawrence, A. (1994). A dissociation in the relation between memory tasks and frontal lobe tests in the normal elderly. Neuropsychologia, 32(12), 1523-1532.
- Penfield, W., & Milner, B (1958). Memory deficit produced by bilateral lesions in the hippocampal zone. Archives of Neurology and Psychiatry, 79, 475-497.
- Phillips, N.A., & McGlone, J. (1995). Grouped data do not tell the whole story: Individual analysis of cognitive change after temporal lobectomy. Journal of Clinical and Experimental Neuropsychology, 17(5), 713-724.
- Phillips, R.R., Malamut, B., Bachevalier, J., & Mishkin, M. (1988). Dissociation of the effects of inferior temporal and limbic lesions on object discrimination learning with 24 hour intertrial intervals. Behavioural Brain Research, 27, 99-107.
- Powell, J.B., Cripe, L.I., & Dodrill, C.B. (1991). Assessment of brain impairment with the rey auditory verbal learning test: A comparison with other neuropsychological measures. Archives of Clinical Neuropsychology, 6, 241-249.
- Pritchard, J.C. (1822). A treatise on diseases of the nervous system, Part One. London.
- Rausch, R. (1985). Differences in cognitive function with left and right temporal lobe dysfunction. In Benson, D.F., & Zaidel, E (Eds) The Dual Brain. New York: Plenum Press.
- Rausch, R. (1992). Role of the neuropsychological evaluation and the intracarotid sodium

- amobarbital procedure in the surgical treatment for epilepsy. In Theodore, W.H. (Ed.) Surgical treatment of epilepsy. New York: Elsevier Science Publishers.
- Rausch, R., & Crandall, P.H. (1982). Psychological status related to surgical control of temporal lobe seizures. Epilepsia, 23, 191-202.
- Rey, A. (1941). L'examen psychologique dans les cas d'encephalopathie traumatique. Archives de Psychologie, 28, 286-340.
- Rey, A. (1964). L'examen Clinique en Psychologie. Paris: Presses Universitaires de France.
- Reitan, R.M. (1969). Manual for Administration of Neuropsychological Test Batteries for Adults and Children. Indianapolis University Medical Center: Unpublished Manuscript.
- Ribbler, A., & Rausch, R. (1989). Performance of patients with unilateral temporal lobectomy on selective reminding procedures using either related or unrelated words. Cortex, 26(4), 575-584.
- Rose, S.W., Penry, J.K. , & Markush, R.E. (1973). Prevalence of epilepsy in children. Epilepsia, 14, 133-152.
- Russell, E.W. (1975). A multiple scoring method for the assessment of complex memory functions. Journal of Consulting and Clinical Psychology, 43, 800-809.
- Sadeh, M., Ariel, R., & Inbar, D. (1996). Rey-Osterrieth and Taylor complex figures: Equivalent measures of visual organization and visual memory in ADHD and normal children. Child Neuropsychology, 2(1), 63-71.
- Saling, M.M., Berkovic, S.F., O'Shea, M.F., Kalnins, R.M., Darby, D.G., & Bladin, P.F. (1993). Lateralization of verbal memory and unilateral hippocampus sclerosis: Evidence of task specific effects. Journal of Clinical and Experimental Neuropsychology.

15(4), 608-618.

- Samson, S., & Zatorre, R.J. (1991). Recognition memory for text and melody of songs after unilateral temporal lobe lesion: Evidence for dual encoding. Journal of Experimental Psychology: Learning, Memory and Cognition, 17(4), 793-804.
- Sass, K.J., Sass, A., Westerveld, M., Lencz, T., Novelly, R.A., Kim, J.H., & Spencer, D.D. (1992). Specificity in the correlation of verbal memory and hippocampal neuronal loss: Dissociation of memory, language, and verbal intellectual ability. Journal of Clinical and Experimental Neuropsychology, 14(5), 662-672.
- Sass, K.J., Spencer, D.D., Kim, J.H., Westerveld, M., Novelly, R.A., & Lencz, T. (1990). Verbal memory impairment correlates with hippocampal pyramidal cell density. Neurology, 40, 1694-1697.
- Sattler, J.M. (1988). Assessment of Children. Third Edition. San Diego: Sattler.
- Saykin, A.J., Gur, R.C., Sussman, N.M., O'Connor, M.J., & Gur, R.E. (1989). Memory deficits before and after temporal lobectomy: Effect of laterality and age of onset. Brain and Cognition, 9, 191-200.
- Schmajuk, N.A. (1984). Psychological theories of hippocampal function. Physiological Psychology, 12(3), 166-168.
- Scoville, W., & Milner, B. (1957). Loss of recent memory after bilateral hippocampal lesions. Journal of Neurology, Neurosurgery and Psychiatry, 20, 11-21.
- Selwa, L.M., Berent, S., Giordani, B., Henry, T.R., Buchtel, H.A., & Ross, D.A. (1994). Serial cognitive testing in temporal lobe epilepsy: Longitudinal changes with medical and surgical therapies. Epilepsia, 35(4), 743-749.
- Shamansky, S.L., & Glaser, G.H. (1979). Socioeconomic characteristics of childhood

- Tramontana, M.G., & Hooper, S.R. (1988). Assessment issues in child neuropsychology. New York: Plenum Press.
- Trenery, M.R., Jack, C.R., & Ivnik, R.J. (1993). MRI hippocampal volumes and memory function before and after temporal lobectomy. Neurology, 43, 1800-1805.
- Trimble, M. (1987). Anticonvulsant Drugs and cognitive function: A review of the literature. Epilepsia, 28, S37-S45.
- Trimble, M., & Reynolds, C. (1987). Epilepsy, behaviour and cognitive function. New York: Wiley Publishers.
- Vaernet, K. (1983). Temporal lobectomy in children and young adults in Parsonage, M., Grant, R.H.E., and Craig, A.G. (Eds.), Advances in Epileptology. The XIVth Epilepsy International Symposium. New York. p. 255-261.
- Vance, B., Mayes, L.M., Eaves, R.C., & Morrison, S. (1993). Concurrent validity of the cognitive levels test with measures of achievement for a sample of children and youth. Journal of Clinical Psychology, 49(1), 72-79.
- Van den Berg, B.J., & Yerushalmy, J. (1969). Studies on convulsive disorders in young children. Pediatric Research, 3, 298-304.
- Ventureyra, E.C.G., & Higgins, M.J. (1993). Complications of epilepsy surgery in children and adolescents. Pediatric Neurosurgery, 19, 40-56.
- Warrington, E.K. (1984). Recognition Memory Test. Windsor, U.K.: NFER-Nelson.
- Wechsler, D. (1974a). Wechsler Intelligence Scale for Children-Revised. New York: Psychological Corporation.
- Wechsler, D. (1974b). Wechsler Memory Scale manual. San Antonio, Texas: The Psychological Corporation.

- Wechsler, D. (1981). Manual for the Wechsler Adult Intelligence Scale. The Psychological Corporation: New York.
- Wechsler, D. (1987). Manual for the Wechsler Memory Scale- Revised. Psychological Corporation: New York.
- Wechsler, D. (1991). Wechsler Intelligence Scale for Children (3rd ed.) San Antonio, Texas: The Psychological Corporation.
- Westerveld, M., Zawacki, T., Spencer, S.S., & Sass, K.J. (1993). Epilepsy surgery in children and adolescents: Cognitive outcome. Abstract from the annual meeting of the American Epilepsy Society. Neuropsychologia, 34(6).
- Wilkins, A., & Moscovitch, M. (1978). Selective impairment of semantic memory after left temporal lobectomy. Neuropsychologia, 16, 73-79.
- Woods, B.T. (1980). The restricted effects of right hemisphere lesions after age one: Wechsler test data. Neuropsychologia, 18, 65-70.
- Wyllie, E., Naugle, R., Awad, I., Chelune, G., Lauders, H., Dinner, D., Skibinski, C., & Ahl, J. (1991). Intracarotid amobarbital procedure: Prediction of decreased modality specific memory scores after temporal lobectomy. Epilepsia, 32(6), 857-864.
- Zola-Morgan, S., Squire, L.R., & Amaral, D.G. (1989). Lesions of the hippocampal formation but not lesions of the fornix or the mammillary nuclei produce long-lasting memory impairment in monkeys. Journal of Neuroscience, 9, 898-913.
- Zola-Morgan, S. & Squire, L.R. (1993). Neuroanatomy of memory. Annual Review of Neuroscience, 16, 547-563.

APPENDIX A
MEMORY TAXONOMY

(Squire, 1992)

APPENDIX B

CLASSIFICATION OF EPILEPTIC SEIZURES
BY THE INTERNATIONAL LEAGUE AGAINST EPILEPSY, 1985.

- I. Partial Seizures (where the initial clinical changes indicate involvement of only one cerebral hemisphere)
 - a. Simple (where consciousness* is not impaired)
 - b. Complex (where there is an impairment of consciousness; may sometimes begin with simple symptomology)
 - c. Those that evolve to secondarily generalized seizures
- II. Generalized Seizures (where the initial clinical changes indicate involvement of both cerebral hemispheres)
 - a. Absence (where there is an interruption of ongoing activities with an impairment of consciousness)
 - b. Myoclonic (described as "shock-like" contractions)
 - c. Tonic (described as tonic muscular contractions)
 - d. Clonic (described as clonic movements)
 - e. Tonic-Clonic (typical "Grand Mal" seizure involving both tonic and clonic movements)
 - f. Atonic (where there is a loss of all muscle tone, also known as drop attacks)

* consciousness is defined by the "degree of awareness and/ or responsiveness of the patient to externally applied stimuli." (Bancaud, 1981.p.492)

APPENDIX C

PRESENCE OF THE FOLLOWING IS OFTEN ASSOCIATED WITH INTRACTABILITY. (LEPPIK, 1992).

Seizure Type

- complex partial seizures
- multiple seizure types
- frequent tonic-clonic seizures
- status epilepticus

Age of onset

- onset in childhood for some syndromes (eg: Lennox-Gastaut)
- onset in adulthood

EEG findings

- slow background
- interictal activity

Etiology

- symptomatic epilepsy

Clinical findings

- abnormal neurological examination
- abnormal neuropsychological testing

Treatment

- delay from time of diagnosis to treatment

APPENDIX D
SUMMARY OF DEMOGRAPHICAL DATA FOR ADULT* SUBGROUP

Sample	Mean (SD)
Age at time of diagnosis	11.6 yrs (11.0)
Age at time of surgery	31.0 yrs (11.0)
Interval between pre-operative and post-operative testing	15.8 months (4.6)
Interval between surgery and post-operative testing	12.8 months (2.2)
Neuropathological reports:	
Tumour	N=7
Architectural abnormalities	N=38
Normal tissue	N=3

Notes:

* Adult is defined as being over 20 years of age.

APPENDIX F

Figure 1. — Drawing of anatomical dissection of the temporal lobe to show the line of surgical resection (arrow) that includes the anterior polar cortex and the amygdala, but with minimal removal of the hippocampus (modified from Feindel and Penfield, 1954)

APPENDIX G

101 Patients Seizure Free Post Temporal Lobectomy**Extent of Removal of Medial Temporal Structures**

APPENDIX H

Table 5

Left and Right Temporal Lobe Group Comparisons on Measures of Intelligence (adult sample, standard scores)

Variable	Left Temporal	Right Temporal		
	Mean (SD)	Mean (SD)	F	p
Full Scale IQ				
pre	88.8 (9.6)	90.4 (11.1)	.04	ns
post	91.0 (8.7)	90.9 (10.7)		
Verbal IQ				
pre	89.3 (9.5)	90.9 (11.5)	.00	ns
post	90.4 (8.1)	91.1 (11.3)		
Performance IQ				
pre	90.1 (10.6)	91.8 (11.8)	.08	ns
post	93.7 (10.0)	92.5 (10.6)		

Table 6

Left and Right Temporal Lobe Group Comparisons on Measures of Intelligence (child sample, standard scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Full Scale IQ				
pre	93.1 (18.7)	88.7 (15.1)	.46	ns
post	91.9 (18.6)	87.9 (12.7)		
Verbal IQ			1.17	ns
pre	91.5 (17.5)	85.1 (13.3)		
post	90.0 (16.9)	81.9 (11.0)		
Performance IQ			.00	ns
pre	95.3 (20.7)	95.1 (16.6)		
post	95.3 (20.7)	97.1 (14.9)		

Table 7

Left and Right Temporal Lobe Group Comparisons on Measures of Verbal Memory (adult sample, raw scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Logical Memory Immediate				
pre	6.3 (2.9)	6.0 (2.7)	.09	ns
post	4.6 (2.1)	6.0 (3.4)		
Logical Memory Delayed				
pre	2.9 (1.8)	3.4 (3.1)	.52	ns
post	2.6 (1.9)	3.6 (2.6)		
Paired Associate Immediate				
pre	12.4 (3.2)	14.5 (3.2)	4.13	.05
post	10.1 (4.1)	14.7 (3.2)		
Paired Associate Delayed				
pre	6.8 (1.9)	7.7 (1.8)	2.81	ns
post	5.4 (2.5)	8.1 (1.8)		
Recognition Memory: Words				
pre	44.3 (3.1)	47.1 (3.3)	6.93	.01
post	41.8 (5.3)	46.6 (3.3)		

Table 8
Left and Right Temporal Lobe Group Comparisons on Percent Retained of Logical Memory
(adult sample)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Logical Memory				
pre	43.8 (15.5)	55.1 (23.0)	3.50	.07
post	48.0 (17.7)	56.4 (23.2)		

Table 9

Left and Right Temporal Lobe Group Comparisons on a Measure of Verbal Memory (child sample, age corrected z scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Sentence Memory				
pre	-.7 (.6)	-1.9 (.7)	7.45	.00
post	-1.3 (.7)	-1.8 (1.1)		

Table 10

Left and Right Temporal Lobe Group Comparisons on a Measure of Spatial Memory (adult sample, raw scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Rey-Osterreith Delay				
pre	14.4 (6.6)	13.2 (4.8)	.58	ns
post	17.3 (5.8)	13.3 (5.7)		

Table 11

Left and Right Temporal Lobe Group Comparisons on Percent Retained of Rey-Osterrieth (adult sample)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Rey-Osterrieth pre	46.4 (18.9)	43.3 (14.4)	.42	ns
post	56.9 (16.3)	45.2 (16.8)		

Table 12

Left and Right Temporal Lobe Group Comparisons on a Measure of Spatial Memory (child sample, age corrected z scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Tactual Performance Test				
pre	-1.4 (1.2)	-1.6 (1.7)	.05	ns
post	-.8 (1.8)	-.3 (1.0)		

Table 13

Left and Right Temporal Lobe Group Comparisons on a Measure of Semantic Memory (adult sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	<u>F</u>	<u>p</u>
Vocabulary				
pre	7.5 (2.7)	7.9 (2.9)	.17	ns
post	7.2 (2.4)	8.4 (3.2)		

Table 14

Left and Right Temporal Lobe Group Comparisons on a Measure of Semantic Memory (child sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Vocabulary				
pre	8.4 (3.0)	7.3 (2.5)	1.02	ns
post	8.2 (2.9)	6.3 (2.5)		

Table 15
Left and Right Temporal Lobe Group Comparisons on Measures of Attention (adult sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Digit Span				
pre	9.2 (2.0)	9.5 (2.3)	.24	.63
post	9.9 (2.1)	10.1 (2.0)		
Arithmetic				
pre	10.3 (2.3)	8.9 (2.2)	4.27	.04
post	9.9 (2.5)	9.5 (2.4)		

Table 16
Left and Right Temporal Lobe Group Comparisons on Measures of Attention (child sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Digit Span				
pre	9.9 (2.4)	7.6 (2.2)	6.42	.02
post	8.6 (2.3)	6.7 (2.5)		
Arithmetic				
pre	7.9 (2.5)	7.1 (2.9)	.60	ns
post	7.5 (2.8)	6.9 (2.7)		

Table 17

Left and Right Temporal Lobe Group Comparisons on a Measure of Achievement (adult sample, standard scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
WRAT-R				
pre	86.9 (14.1)	89.2 (14.8)	.26	ns
post	83.6 (13.6)	89.1 (15.1)		

Table 18

Left and Right Temporal Lobe Group Comparisons on a Measure of Achievement (child sample, standard scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
WRAT-R				
pre	97.2 (17.4)	87.3 (24.3)	.94	ns
post	88.4 (18.6)	100.2 (16.4)		

Table 19

Left and Right Temporal Lobe Group Comparisons on Measures of Executive Functioning (adult sample, raw scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Oral Fluency				
pre	11.8 (3.0)	12.1 (4.0)	.07	ns
post	13.6 (4.8)	13.7 (4.8)		
WCST				
pre	4.7 (1.8)	5.2 (1.5)	.61	ns
post	4.3 (2.3)	4.7 (2.1)		

Table 20

Left and Right Temporal Lobe Group Comparisons on Measures of Executive Functioning (child sample, age corrected z scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Oral Fluency				
pre	-.3 (0.8)	-.8 (1.3)	.79	ns
post	-.3 (0.8)	-.9 (0.9)		
Category Test				
pre	.7 (0.9)	.2 (1.1)	1.64	ns
post	.1 (1.1)	-.2 (1.0)		

Table 21
Left and Right Temporal Lobe Group Comparisons on Measures of Perceptual Functioning
(adult sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Picture Arrangement				
pre	8.9 (3.0)	7.9 (3.2)	.78	ns
post	10.1 (3.3)	8.6 (2.2)		
Picture Completion				
pre	8.9 (3.4)	8.1 (2.7)	.56	ns
post	8.9 (2.3)	8.4 (2.6)		
Rey-Osterrieth Copy				
pre	30.5 (3.4)	30.2 (3.0)	.07	ns
post	29.9 (3.1)	29.1 (3.4)		

Table 22
Left and Right Temporal Lobe Group Comparisons on Measures of Perceptual Functioning
(child sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)	F	p
Picture Arrangement				
pre	8.6 (4.5)	9.2 (4.4)	.11	ns
post	9.5 (3.9)	8.5 (3.8)		
Picture Completion				
pre	9.2 (3.6)	8.8 (3.2)	.08	ns
post	9.3 (3.4)	8.7 (4.1)		

APPENDIX I

Table 23

Left and Right Temporal Lobe Group Comparisons on Measures of Intelligence (adult tumour sample, standard scores)

Variable	Left Temporal (n=3) Mean (SD)	Right Temporal (n=4) Mean (SD)
Full Scale IQ		
pre	96.7 (10.7)	99.5 (13.8)
post	99.7 (17.6)	101.0 (13.4)
Verbal IQ		
pre	101.3 (12.1)	101.3 (13.3)
post	99.3 (17.2)	100.8 (12.3)
Performance IQ		
pre	93.0 (8.7)	98.3 (13.0)
post	101.3 (18.7)	102.0 (12.5)

Table 24
Left and Right Temporal Lobe Group Comparisons on Measures of Intelligence (child tumour sample, standard scores)

Variable	Left Temporal (n=5) Mean (SD)	Right Temporal (n=2) Mean (SD)
Full Scale IQ		
pre	107.0 (13.8)	106.0 (8.5)
post	102.4 (19.0)	93.5 (9.3)
Verbal IQ		
pre	102.6 (10.9)	105.0 (4.2)
post	101.2 (15.8)	90.0 (11.3)
Performance IQ		
pre	110.6 (19.6)	105.0 (12.7)
post	103.6 (22.7)	99.5 (3.5)

Table 25

Left and Right Temporal Lobe Group Comparisons on Measures of Verbal Memory (adult tumour sample, raw scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
Logical Memory Immediate		
pre	9.7 (3.6)	7.5 (4.3)
post	6.5 (3.3)	7.5 (3.7)
Logical Memory Delayed		
pre	4.9 (2.1)	4.2 (3.8)
post	3.9 (2.2)	4.3 (4.9)
Paired Associates Immediate		
pre	14.2 (4.8)	12.6 (4.6)
post	13.5 (4.8)	14.3 (4.3)
Paired Associates Delayed		
pre	7.7 (1.5)	6.5 (1.9)
post	6.7 (2.1)	7.5 (2.1)
Recognition Memory: Words		
pre	43.0 (6.9)	48.8 (1.0)
post	43.7 (1.2)	45.0 (4.1)

Table 26

Left and Right Temporal Lobe Group Comparisons on Percent Retained of Logical Memory
(adult tumour sample)

Variable	Left Temporal	Right Temporal
	Mean (SD)	Mean (SD)
Logical Memory		
pre	50.7 (8.5)	62.3 (5.2)
post	57.7 (7.1)	63.1 (26.2)

Table 27

Left and Right Temporal Lobe Group Comparisons on a Measure of Verbal Memory (child tumour sample, age corrected z scores)

Variable	Left Temporal	Right Temporal
	Mean (SD)	Mean (SD)
Sentence Memory		
pre	-.7 (0.6)	-.6 (0.3)
post	-.9 (0.6)	-.8 (2.1)

Table 28
Left and Right Temporal Lobe Group Comparisons on a Measure of Spatial Memory (adult
tumour sample, raw scores)

Variable	Left Temporal	Right Temporal
	Mean (SD)	Mean (SD)
Rey-Osterrieth Delay		
pre	17.5 (5.2)	16.9 (1.2)
post	19.2 (4.5)	16.0 (8.7)

Table 28

Left and Right Temporal Lobe Group Comparisons on Percent Retained of Rey-Osterrieth (adult tumour sample)

Variable	Left Temporal	Right Temporal
	Mean (SD)	Mean (SD)
Rey-Osterrieth		
pre	56.3 (7.5)	55.4 (2.8)
post	62.6 (9.3)	53.3 (3.4)

Table 29

Left and Right Temporal Lobe Group Comparisons on a Measure of Spatial Memory (child tumour sample, age corrected z scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
Tactual Performance Test		
pre	-.8 (1.5)	-.9 (3.1)
post	.2 (1.8)	-.1 (1.9)

Table 30
Left and Right Temporal Lobe Group Comparisons on a Measure of Semantic Memory (adult
tumour sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
Vocabulary		
pre	10.0 (3.6)	11.7 (0.6)
post	10.3 (3.2)	12.3 (0.6)

Table 31

Left and Right Temporal Lobe Group Comparisons on a Measure of Semantic Memory (child tumour sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
Vocabulary		
pre	10.2 (2.8)	10.0 (1.4)
post	10.0 (2.5)	7.0 (1.4)

Table 32
Left and Right Temporal Lobe Group Comparisons on Measures of Attention (adult tumour sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
Digit Span		
pre	9.3 (3.1)	11.4 (2.1)
post	10.0 (3.6)	11.0 (2.0)
Arithmetic		
pre	11.7 (3.8)	9.7 (2.2)
post	10.7 (3.1)	11.1 (2.8)

Table 33

Left and Right Temporal Lobe Group Comparisons on Measures of Attention (child tumour sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
Digit Span		
pre	11.0 (1.2)	9.5 (2.1)
post	10.1 (2.3)	7.5 (0.7)
Arithmetic		
pre	9.0 (1.6)	11.0 (0.1)
post	8.6 (2.9)	9.0 (2.8)

Table 34
Left and Right Temporal Lobe Group Comparisons on a Measure of Achievement (adult tumour sample, standard scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
WRAT-R	97.3 (7.6)	97.8 (6.8)
pre	90.7 (8.1)	91.5 (7.6)
post		

Table 35

Left and Right Temporal Lobe Group Comparisons on a Measure of Achievement (child tumour sample, standard scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
WRAT-R		
pre	103.2 (13.4)	109.5 (0.7)
post	88.7 (17.2)	117.0 (7.1)

Table 36

Left and Right Temporal Lobe Group Comparisons on Measures of Executive Functioning (adult tumour sample, raw scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
Oral Fluency		
pre	10.7 (3.8)	8.3 (5.0)
post	12.3 (2.9)	10.5 (9.2)
WCST		
pre	3.0 (0.1)	6.6 (0.1)
post	5.5 (0.7)	6.6 (0.2)

Table 37
Left and Right Temporal Lobe Group Comparisons on Measures of Executive Functioning (child
tumour sample, age corrected z scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
Oral Fluency		
pre	-.1 (0.7)	.3 (1.7)
post	.2 (0.5)	.3 (0.3)
Category Test		
pre	.2 (0.9)	-.2 (1.9)
post	-.4 (1.5)	-1.3 (0.1)

Table 38

Left and Right Temporal Lobe Group Comparisons on Measures of Perceptual Functioning
(adult tumour sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
Picture Arrangement		
pre	10.3 (2.1)	7.3 (0.6)
post	14.0 (5.2)	7.7 (0.6)
Picture Completion		
pre	8.7 (2.1)	10.0 (2.0)
post	8.7 (3.8)	10.3 (2.3)
Rey-Osterrieth Copy		
pre	30.7 (6.1)	30.5 (1.7)
post	30.3 (3.1)	29.3 (5.0)

Table 39
Left and Right Temporal Lobe Group Comparisons on Measures of Perceptual Functioning
(child tumour sample, scaled scores)

Variable	Left Temporal Mean (SD)	Right Temporal Mean (SD)
Picture Arrangement		
pre	12.5 (3.0)	13.0 (7.1)
post	10.8 (5.1)	9.0 (1.4)
Picture Completion		
pre	11.4 (4.0)	11.5 (0.7)
post	11.0 (3.9)	10.0 (1.4)

IMAGE EVALUATION TEST TARGET (QA-3)

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