PERFORMANCE AND EFFECTIVENESS OF STRATEGY USE ON THE REY AUDITORY VERBAL LEARNING TEST AFTER TRAUMATIC BRAIN INJURY AND IN A CONTROL POPULATION

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ABSTRACT

Clinical assessment of memory is important for the diagnostic understanding, management and rehabilitation of individuals with significant brain dysfunction. The present study investigated ways in which disorganised thinking or impaired information processing contribute to memory problems in survivors of traumatic brain injury (TBI). Memory performance on the Rey Auditory-Verbal Learning Test was assessed for 141 TBI patients and 59 controls and the relative effectiveness of different strategies was evaluated. Results showed a significant main effect between group scores with controls demonstrating progressively superior performance across trials. The range of learning strategies observed across both groups were condensed into three sub-categories. Subjects who employed no strategies at all performed less well than those who used passive strategies, who in turn performed less well than subjects who adopted active strategies. This latter group obtained the highest memory scores in their respective TBI or control groups. However, a temporal effect was evident in that unlike controls who maintained their best performance from initial trials to delayed recall, TBI subjects showed a marked decline in long term memory recall. Taken together, these findings suggest that the ability to initiate, maintain and transfer learning strategies depends on intact meta-cognitive processes such as executive functioning and metamemory, whereby the individual actively employs effective learning strategies. This is an effortful and elaborative process that demands vigilance and planning. When such functions are compromised, as commonly occurs in TBI patients, subsequent learning abilities may be progressively constrained. Where some residual learning ability is indicated, retraining programmes should focus on the development of self-monitoring and other metacognitive skills before instruction in mnemonic techniques.

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CHAPTER ONE

INTRODUCTION

Memory dysfunction is a common outcome after traumatic brain injury (TBI) and this is typically reflected in neuropsychological assessment measures where memory is involved. However clinicians have observed large individual differences on these measures which are not always clearly attributable to the extent of organic tissue damage. Sometimes it has appeared that deficits in the ability to organise and plan for learning, also common sequelae of TBI, may undermine performance on memory measures.

The present study examined the effect of TBI on verbal memory and the efficacy of various strategies used in verbal learning. The Rey Auditory Verbal Learning Test (AVLT; Rey, 1964; Lezak, 1983) was chosen as the verbal memory task for the study because of its widespread acceptance as an effective and valid measure of verbal learning and memory and also because as a free-recall rather than cue-recall measure, it gives information about rates and strategies for learning.

In order to provide a context for the study, an overview of TBI is provided in Chapter two, with an emphasis on outcomes. Memory in particular is developed in Chapter three, especially those theories and aspects of memory associated with acquisition in verbal memory. Two theories reviewed include a temporal model featuring components of short term memory and long term memory and a levels-of-processing model which promotes deeper semantic processing for optimal learning.

Strategies employed in verbal learning and a review of studies reporting the efficacy rates for different strategies is presented in Chapter four. A summary of the rationale and background for the study is provided in Chapter five and leads into the specific hypotheses examined. Methodology is presented in Chapter six and the results of each hypothesis presented in Chapter seven. These are discussed in Chapter eight in terms of their theoretical implications in the areas of memory and rehabilitation. Suggestions for further research and implications for the future are presented.

CHAPTER TWO

TRAUMATIC BRAIN INJURY (TBI)

> *Traumatic head injury is an insult to the brain, not of a degenerative or congenital nature but caused by an external physical force, that may produce a diminished or altered state of consciousness, which results in impairment of cognitive abilities or physical functioning. It can also result in the disturbance of behavioural or emotional functioning. These impairments may be either temporary or permanent and cause partial or total functional disability or psychosocial maladjustment.*
>
> (The National Head Injury Foundation, 1986, cited in Forgette, 1989, p.379).

2.1. EPIDEMIOLOGY

Traumatic brain injury is surpassed only by stroke as the most common cause of neuropathology. However this is probably an understatement of the problems since incidence figures usually include only those patients who are hospitalised and not those with mild TBI who attend a general practitioner or do not seek medical assistance at all.

Hospital admissions figures after TBI are consistent across Western nations ranging from 200 per 100,000 in the United States to 300 per 100,000 in Denmark. Of these, 80% were simple concussions and 20% were more severe TBI (Astrup, 1989). In New Zealand, the overall prevalence of TBI is approximately 288 per 100,000 per year. Of these, 14% sustain severe TBI and 10% are hospitalised for more than twenty days. Traumatic brain injury accounts for 50% of all deaths due to trauma in persons aged between 1-44 years and is the principle cause of death amongst those aged 15-45 years. Males account for two-thirds of those injured. Because TBI is more common amongst young people there is a dual cost to society, both in lost wages and production for those unable to return to work, and in the ongoing costs of patient care and rehabilitation (Gronwall, Wrightson & Waddell, 1990).

2.2. CAUSES OF HEAD INJURY

In a sense, the victims of TBI are not a random sample. They include a disproportionate number who exhibit various kinds of social excess. They are more likely to take risks in cars and on motorcycles, often in combination with high alcohol intake and are likely to have had multiple concussive episodes (Gronwall, Wrightson & Waddell, 1990). Motor vehicle accidents account for the greatest proportion (49%) of TBI and 50% of these involve alcohol. Other causes of head injury in order of occurrence are assaults, sports injuries, falls and industrial accidents. Approximately 14% of head injuries are related to missile or gunshot wounds (Morse & Montgomery, 1992).

These authors further suggest that those with TBI have higher than usual histories of learning disability and parents who do not adequately teach their children about the consequences of risk taking and who allow children to climb or play in dangerous places. As adolescents, these same individuals may extend their risk taking behaviour into such pursuits as dangerous motor vehicle driving and\or abuse of alcohol or drugs.

2.3. CLASSIFICATIONS OF HEAD INJURY

Classifications of TBI are not mutually exclusive, but overlap and more than one may occur simultaneously in individual cases.

2.3.1. Blunt, Sharp and Compressive TBI

Since motor vehicle accidents account for the majority of TBI, it follows that blunt head injury is the most common result. Blunt head injury occurs predominantly after deceleration, (where the moving person collides with a stationary object, such as the dashboard in a motor vehicle accident) but also by acceleration (where a stationary person is hit by a moving object, for example, a pedestrian being hit by a car). In either case, the pathological sequelae may include skull whiplash, twisting of the cerebrum on top of the brain stem and widespread shearing of blood vessels and nerve fibres in the brain (Lezak, 1983).

Sharp head injury involves penetration of the skull by external objects such as missiles, gunshots, bomb fragments, swords, knives, golf balls or fragments of the skull itself. The degree of TBI depends on the size and speed of the penetrating object, the angle at which it impacts, the strength of the skull at various points and the size and strength of affected vessels in the brain. The result is often localised damage which may be less damaging in the long term, but is more likely to lead to post-traumatic epilepsy than blunt TBI.

Compressive head injury occurs when the skull is compressed by a heavy object, for example, when a car falls from a jack, or when a person is trapped between a truck and a wall.

2.3.2. Closed and Open TBI

Superimposed on the blunt-sharp-compressive distinction, is the open-closed dichotomy. Closed head injury (CHI), the most common type of TBI, results from a blow to the head which does not produce a disruption in the continuity of the skull or dura, but could alter the individual's consciousness (Groher, 1977, p.213).

Open head injury occurs when the brain is exposed to the outside environment through skull fracture. Apart from the direct damage to the brain tissue, other risks arise from skull fragments being driven into the brain tissue, as in compound fracture, and infection from outside contaminants.

2.3.3. Mild, Moderate and Severe TBI

Traumatic brain injury can range from severe through moderate to mild and is commonly defined by the patient's level of consciousness as measured by the Glasgow Coma Scale (GCS) (Jennett & Teasdale, 1981), or duration of loss of consciousness (LOC). A score of 8 or less on the GCS is considered a severe TBI. A score between 9-11 or 12 represents a moderate TBI, and a score of 12 or 13-15 is a mild head injury (also known as post concussive syndrome) (Morse & Montgomery, 1992). The GCS, whilst a useful measure of severity, is used only with hospital admissions.

Mild head injury is sometimes defined as having a LOC of less than 30 minutes and the absence of skull fracture. However, health professionals often prefer another more useful measure - the duration of post-traumatic amnesia (PTA). This refers to the interval between the injury and subsequent recovery of continuous memory for day to day events (sometimes including the duration of any coma). Post-traumatic amnesia periods greater than one day (24 hours) are associated with severe TBI. Periods of PTA lasting between one and twenty four hours represent moderate TBI whilst patients with less than one hour of PTA are considered to have suffered a mild head injury (Morse & Montgomery, 1992).

Concussion refers to a temporary state of brain dysfunction in which there is loss of consciousness and amnesia without gross structural changes in the brain (Astrup, 1989) and is caused as rotational velocity affects the brain stem reticular formation. The victim typically feels confused and disoriented on waking and may complain of memory difficulties. Previously, it was thought that recovery from concussion occurred without serious neurological deficit but recently, significant changes have been observed in nerve cells, their axons and fibre tracts. Lezak (1983) reports widespread white matter and cortical tissue damage associated with concussion.

Concussion has been graded in four levels of severity: Grade 1, the mildest results in transient confusion with rapid return to normal consciousness and no anterograde amnesia. Grades 2 and 3, are given when there is increasing confusion. Grade 4 is given when there is loss of consciousness, confusion, post traumatic amnesia and retrograde amnesia. In cases of serious concussion, the patient may suffer post-concussion syndrome, the symptoms of which include headache, nausea, difficulty in concentration, insomnia and depression. Patients may underestimate the effect of concussion and may find their work performance sluggish in ensuing weeks (Lezak, 1983).

However, distinctions between mild and severe, may not always be definitive. For example, patients with mild TBI may go on to experience significant difficulties in functioning for some time, whilst other moderate TBI patients may fare better, only exhibiting "high level" problems in their later stages of recovery (Morse & Montgomery, 1992, p. 85).

2.4. NEUROPATHOLOGY

2.4.1. Primary Injury

Traumatic brain injury causes two types of lesions, diffuse or focal, which may occur simultaneously.

Diffuse Axonal Injury (DAI) describes widespread cerebral damage resulting from acceleration or deceleration mechanisms. Injury stems from shearing of axons or disruption of neuronal membrane permeability with consequential loss of electrical transmission. Diffuse axonal injury is a principal cause of cognitive impairment following TBI producing slower neuronal processing in areas such as thinking, analysing, processing and the integrating of information. It may be present even where there is no loss of consciousness (Morse & Montgomery, 1992).

Focal Injury occurs in specific areas of the brain and its effect depends upon the magnitude and location of impact. Contusions may affect cerebral tissue both in the vicinity of impact and in areas opposite - the coup-contrecoup phenomenon. Bruising is sometimes greater at the contrecoup site than the site of impact. For example, impact in the frontal region may frequently result in occipital lobe injury. Approximately half of all focal injuries caused by impact to the side of the head are located at the contrecoup site (Morse & Montgomery, 1992).

Focal areas commonly affected by contusions include "the basal frontal and temporal lobes, the cingulate gyri, the tip of the temporal lobes and the frontal poles" (Morse & Montgomery, 1992, p.89). Further brain damage in CHI results from the combined effects of "translatory forces and rotational acceleration" (Lezak, 1983, p.167) within the confined structure of the skull. Such brain movement may cause stretching or shearing of fine nerve fibres and blood vessels. The frontal and temporal lobes are particularly vulnerable to the microscopic lesions that result.

2.4.2. Secondary Injury

Indirect brain injury often continues after the initial impact and may result from external systemic sources or further intracranial processes. Moderate to severe cases of head trauma typically include systemic injuries involving vascular or respiratory disturbance (Lezak 1983). Damage caused by haemorrhage occurs when blood flows in between the layers of the brain and acts as a growing contaminating mass which exerts increasing pressure on soft brain structures. Haemorrhage may also lead to anaemia when blood flows to brain extremities are disrupted. Further systemic disturbance may include arterial hypoxia caused by obstruction of air passages, hypercapnea - increased carbon dioxide in the blood stream, arterial hypotension - bleeding from visceral injury and hypoglycaemia - abnormally low blood sugar levels (Morse & Montgomery, 1992, p.90).

Damage to brain tissue is compounded by swelling due to edema which causes increased intracranial pressure. Factors which trigger edema include vasogenic edema - the extracellular buildup of protein rich fluid following contusions; cytotoxic edema - an intracellular fluid increase caused by cells dying from hypoxic or ischemic damage; ischemic edema - failure of the ventricular system with subsequent increase of cerebral blood volume, and hydrocephalus - obstruction of the flow or absorption of cerebrospinal fluid (Morse & Montgomery, 1992, p.90).

Other intracranial processes include vasospasm - a narrowing of the arteries often associated with subarachnoid haemorrhage, epilepsy - involving increased metabolic demand with risk of subsequent hypoxia, and infection such as meningitis or abscesses all of which produce secondary brain injury. Certain cerebral regions are particularly susceptible to secondary brain damage. Areas vulnerable to distortion or herniation include, the cingulate gyrus, mesial portion of the temporal lobe (particularly the parahippocampal gyri), the oculomotor nerve (cranial nerve III) and brain stem. Brain structures with high metabolic demand include the hippocampus, basal ganglia, cerebellum and cortex (Morse & Montgomery, 1992, p.90).

2.5. DEVELOPMENTAL ASPECTS OF HEAD INJURY

Traumatic brain injury in children may occur from a range of accidents: sporting activities, falling from trees, rocks, or building structures, bicycle injuries, as pillions on motor cycles or passengers in motor vehicles. Where children do sustain a serious TBI, the prognostic outcome may well involve significant impairment in certain areas of functioning for much of their lives. For example, in the case of frontal lobe damage, subsequent failure of the as-yet-undeveloped frontal lobes to mature may result in long term impairment of executive, reasoning, behavioural-personality functioning in the child, and continued pre-adolescent (concrete) thinking in later years (Morse & Montgomery, 1992). There is some evidence supporting the effects of cumulative head injuries. Morse & Montgomery (1992) suggest that earlier head injuries may contribute to individuals showing poor judgement on subsequent occasions that lead to further, possibly more serious TBI. Gronwall (1989, cited in Morse & Montgomery, 1992) reports that adults with a developmental history of head injury sometimes suffer longer lasting sequelae after a mild TBI than do other mild TBI patients. There are therefore considerable differences between children and adults in both causes and outcomes of TBI. For these reasons the present study focused on TBI patients in the fifteen to fifty years age.

2.6. OUTCOMES OF TRAUMATIC BRAIN INJURY

> *If learning ability is impaired, then learning to learn will also be impaired. Learning does not improve with exercise, it is not a muscle but an anatomically sited, electro-chemically based neurophysiological process.*
>
> (Lezak 1987, cited in Meier, Benton & Diller, 1987, p.261).

Early studies identified various factors said to influence the recovery of a patient's post-traumatic intellectual performance. These include the **site** and severity of the injury and **age of the patient**. Others include the **time elapsed since injury** and the **complexity of the activity** (Lezak, 1979). Levin, Grossman, Rose and Teasdale (1979) report **severity** of TBI as the most important factor in determining the level of a patient's improvement. Good outcomes are associated with PTA duration of less than two weeks whereas longer periods usually mean greater impairment and subsequent dependency. The greatest amount of spontaneous improvement occurs in the first 3-6 months following TBI. Further improvement may follow in the next year or two, but at a diminishing rate. Two or three years after their accident most patients with TBI have reached a plateau and subsequent test performances do not change greatly.

Lezak (1987, cited in Meier et al., 1987) reports that those who have the most difficulty returning to an independent lifestyle are patients with moderate to severe

TBI involving diffuse lesions in the pre-frontal, right hemisphere or limbic system structures. In such cases two particular behavioural areas may affect rehabilitation efforts, firstly, the patient's ability to take the abstract attitude, and secondly, the integrity of the executive system. Whether these two capacities become a permanent deficit or are merely compromised, the patient is unlikely to achieve social independence.

The ability to take the abstract attitude implies being able to appreciate the point of view of others and not to be bound by concrete thinking and literal interpretations. Lezak (1987, cited in Meier et al., 1987) is careful to distinguish this from the ability to reason abstractly, citing cases of brain damaged patients who score highly on proverbs or tests of interpretation, yet who fail to exhibit empathy or who behave inappropriately in social settings.

Executive functioning occurs "when the subject spontaneously changes a control process or sequence of control processes as a reasonable response to an objective change in an information processing task." (Butterfield & Belmont, 1977, cited in Pressley & Levin, 1983, p.115). Executive functioning involves the ability to initiate and direct action and includes the formulation, planning and organisation of goal directed behaviour, the carrying out of that behaviour with monitoring and self correcting as necessary. Where executive functioning is compromised, the patient may have no thoughts or plans that come to mind and therefore will continue to do nothing unless prompted by some external source or person. Alone again, it will not occur to the patient to look for cues that could prompt appropriate actions (Lezak, 1987, cited in Meier et al., 1987).

Several factors may influence the social outcome area. Firstly, the patient's pre-morbid levels of intelligence, personality and social adjustment are often an important indicator of post-injury outcome (Levin & Eisenberg, 1991). Such characteristics may become exaggerated following TBI so that certain behavioural tendencies, for example, hypochondriasis, passivity, perfectionism, dependency or irresponsibility become impediments to the active re-learning of old or new skills. Secondly, outcome may be influenced by the level and quality of support from family and friends. Those patients with stable emotional and physical support show better adjustment than those who lack an adequate support system.

2.7. TRAUMATIC BRAIN INJURY AND MEMORY

Memory difficulty after TBI can be distinguished in various ways. The first distinction is based on time of acquisition, that is, old pre-morbid retrograde memory versus new post-injury, or anterograde memory. A second distinction considers how memory is assessed. Thus, in declarative memory, the patient talks about what they know, whereas in procedural memory, patients demonstrate their knowledge by doing things. Both retrograde and anterograde memory may be assessed by either the declarative or procedural method although the latter is rarely called for. The third distinction involves the modality of stimulus presentation. For example, typical test materials may distinguish between auditory-verbal and visual-spatial functioning, which in turn, may be applied in any or all of the retrograde/anterograde and declarative/procedural combinations. Finally, perhaps the most important area involves distinguishing between the stages of processing for declarative memory, that is, encoding, storage and retrieval. Whereas some TBI patients suffer significant retrograde memory problems, others may have difficulty with the encoding and storage of new information in declarative memory, whilst still others may experience big differences between their auditory-verbal and visual-spatial memory performances. However the most common finding is "that TBI patients consistently and frequently demonstrate problems with retrieval of anterograde-declarative memories" (Morse & Montgomery, 1992, p. 123).

Essentially, memory disturbance is a common effect of TBI (Cermak, 1982; Schacter & Crovitz, 1977). The effects of intact versus compromised memory processes have greatest relevance in their impact upon learning. The following chapter begins with an overview of the construct memory and proceeds to discuss impaired verbal learning ability in particular, amongst patients with TBI.

In conclusion, this study chose for its subjects, predominantly individuals with blunt, closed head injuries, who had sustained these injuries over the age of 15 years. There was a spread between mild, moderate and severe categories of injury as determined by period of post traumatic amnesia, (in the absence of GCS and detailed medical records).

CHAPTER THREE

MEMORY

3.1. INTRODUCTION

> *Memory must be considered one of the most pervasive aspects of our mental life. Memory function reflects our experience of the past and allows us at each moment to adapt ourselves to the present and look forward to the future. It is critical to the acquisition and utilisation of new information. It is involved with every aspect of how we think, what we do, and how we behave.*
>
> (Sohlberg & Mateer, 1989, p.136).

Memory describes the ability of living organisms to acquire, retain and make use of information or knowledge. It is commonly associated with learning but the distinction between each should not be confused. Whereas learning refers to just the first phase of memory - that is the gradual acquisition of new skills, behaviours, knowledge and experiences, memory involves the storage and consolidation of such schema over time, as well as their subsequent retrieval (Reed,1988).

Memory has been studied since the times of the early philosophers Plato and Aristotle and for many years has been the domain of experimental psychologists. Some researchers have sought a discrete location for memory function whilst others have held that memory can be disturbed by a lesion almost anywhere. Contemporary theorists now largely accept that stored memory is not restricted to a particular brain area, but rather occurs through the neuronal contributions of many cortical and subcortical sites. Further, storage and retrieval of information occurs according to principles of association, the breakdown of which is a contributory factor in memory disorders (Lezak, 1983). More recently, neuropsychologists have developed models of memory for clinical use, paying particular attention to the ways in which various brain structures maintain normal memory functions. Russell (1975, cited in Filskov & Boll, 1981, p.288) defines memory as *a persistent central nervous system change consisting of both environmental information and activities of the organism that can be reproduced by the organism after some interval of time in an exact or equivalent form.*

3.2. BIOCHEMISTRY OF MEMORY

Early anatomical research reported the multiple interconnections between neurons in the brain. Each neuron transmits either excitatory or inhibitory signals via the multiple synapses on its dendrites and cell body (Hebb, 1949 cited in Kolb & Whishaw, 1990, p.528). This process creates many neuronal loops which may be confined to the cortex or may extend from the cortex to subcortical structures (thalamus, hippocampus) and back again. Hebb hypothesised that every memory, sensation, perception, thought or emotion occurs as a function of this flow of activity in the various neuronal loops.

Hebb further proposed that if two neurons regularly fire together, some metabolic change or growth process takes place to link them functionally, because the synaptic knobs grow to increase the area of contact between the afferent axon and the efferent cell body and its associated dendrites. The process is initiated by a particular sensory event but with repetition is able to continue its activity after the stimulation has ceased (Kolb & Whishaw, 1990). Hebb ascribed the repeated activation of the closed loops of the cell assembly to short-term memory (STM), whereas he saw long-term memory (LTM) resulting from the more structural lasting changes in synaptic connections. As a further prerequisite for LTM, the cell assembly must be left relatively undisturbed for a time (fifteen minutes to one hour) to allow the structural changes to consolidate.

More recent research (Goddard, 1980, Bliss & Gardner Medwin, 1973, cited in Kolb & Whishaw, 1990, p. 529) reports physiological confirmation for the existence of separate neurological substrates for STM and LTM, and tentative support for Hebb's (1949) theory. However, there remains little understanding of what changes take place in the brain to make the synapse more efficient and to invoke memory. A further area not well understood is the effect of lesions on memory - for example, the differential effects of temporal lobe lesions on STM or parietal lobe lesions on LTM.

3.3. NEUROANATOMY AND MEMORY

Memory loss is generally said to be associated with five regions of the brain: " the anterior temporal cortex, the medial temporal region, the medial thalamus, mamilliary bodies and basal forebrain" (Kolb & Whishaw, 1990, p. 533). The temporal, frontal, and parietal lobes have complementary roles in memory. The frontal lobe is implicated in STM in that the hippocampus and amygdala send part of their output to the pre-frontal area of the cerebral cortex. Damage in this area results in difficulty remembering the order of events, or planning the order of movements (Kalat, 1988). The parietal lobe also contributes to STM (Kolb & Whishaw, 1990). Left parieto-temporal lesions greatly impair an individual's ability to recall strings of digits. The parieto-temporal region is involved in retaining verbal material in the left hemisphere, and non-verbal material in the right hemisphere. The temporal lobe is strongly implicated in the study of memory. The case of H.M. and others highlights the importance of the mesio-temporal region in memory and indicates that bilateral removal of the medial temporal lobes including the hippocampus and amygdala results in anterograde amnesia. Damage to Brodman's area 21 leads to memory disturbance which increases in direct proportion to the amount of hippocampus damaged.

Further studies have examined the lateralised contributions of each temporal region. With unilateral temporal lobectomies, subtle memory deficits have been detected that differentiate not only ablations of the left or right temporal lobe, but also correlate the degree of memory loss with the amount of hippocampus removed (Heilman & Valenstein, 1985). Lesions of the left temporal lobe cause impaired recall of verbal material - for instance, short stories or word lists, whether presented visually or aurally. On a short term memory task where a distracter technique is included, left temporal patients show faster decay of nonsense syllables than do right temporal patients (Heilman & Valenstein, 1985). Lesions of the right temporal lobe cause impaired recall of (non-verbal) visual-spatial material, for instance geometric drawings, faces and tunes (Kolb & Whishaw, 1990).

A study by Fedio and Van Buren (1974, cited in Heilman & Valenstein, 1985) in which patients were presented with a naming and memory task, uncovered two distinct areas in the left temporal lobe that affected the patients' recall. Electrical stimulation of the anterior section of the left temporal lobe resulted in anterograde amnesia. Similar stimulation of the posterior temporo-parietal region produced retrograde amnesia. This finding led researchers to suggest that the anterior region (for example, the hippocampus) is associated with the consolidation and storage of verbal information, whilst sectors of the posterior region may be important for the retrieval of stored verbal stimuli. In contrast, patients with right temporal lobectomies suffer greater impairment in processing non-verbal information. Heilman and Valenstein (1985) make no reference to a similar anterior-posterior differentiation in the function of the equivalent right side. However, Smith and Milner (1981, cited in Heilman & Valenstein, 1985) report evidence implicating the right temporal region in 'incidental' learning of the spatial location of self and objects.

3.4. CLASSIFICATIONS OF MEMORY

3.4.1. Verbal and Visual Memory

Traditionally, verbal and visual memory have been thought to be the responsibility of different parts of the brain. Auditory-verbal memory is associated with the dominant (usually left) hemisphere, whereas visuo-spatial memory is associated with the non-dominant (usually right) hemisphere (Morse & Montgomery, 1992). However, challenges to this conventional distinction have been reported, for example, Loring, Lee, Martin & Meador (1989) found that some right temporal lobectomy patients performed worse on the verbal than visual memory subtests of the Wechsler Memory Scale - Revised (WMS-R). Further, the presence of other focal injuries (contusions, skull fractures, sub-dural haematomas) may also contribute greatly to memory problems in one modality, particularly in moderate to severe cases (Morse & Montgomery, 1992).

Many of the temporal lobectomies performed have involved such neuroanatomical structures as the amygdala, uncus, hippocampus, parahippocampal gyrus and anterior temporal neocortex. However, lesions in the hippocampus are critical to memory, with the degree of memory deficit being correlated to the amount of hippocampus removed (Heilman & Valenstein, 1985). Extensive ablation of the left hippocampus results in impaired STM for learning digit sequences while extensive lesions of the right hippocampus result in impaired performance on such tasks as "maze learning, facial recognition from photographs, image-mediated verbal learning and incidental spatial learning" (Corsi, 1969, cited in Heilman & Valenstein, 1985, p.421).

Greene and Crowder (1984) report that auditory presentation results in better immediate recall of the last few items on a word list than visual presentation. They attribute this advantage for auditory presentation to an echoic memory store that is sustained for at least a few seconds, although susceptible to decay and interference. Since TBI typically involves bilateral injury, there are likely to be difficulties with both visual and verbal memory.

3.4.2. Procedural & Declarative Memory

Procedural memory refers to motor learning which is typically unimpaired after TBI and is not examined in this study. Declarative memory according to Tulving's (1972) model of long-term memory may be separated into two distinct memory systems: episodic and semantic memory. Both of which can be disturbed in patients with impaired frontal lobe function due to TBI. Episodic memory refers to recall of information about temporally dated episodes or events, and temporal-spatial relations among these events. It is an autobiographical record of episodes unique to an individual's experience, encoded in a particular time and place context. Semantic memory is the memory necessary for the use of language. It is a mental thesaurus, organised knowledge a person possesses about words and other verbal symbols, their meanings and referents, about relations among them, and about rules, formulas, and algorithms for the manipulation of these symbols, concepts and relations which are common to most people.

3.4.3. Metamemory

Whereas metacognition refers to knowledge of our own cognitive processes, metamemory can be described as "cognition about memory in general, or specific knowledge about the workings of one's own memory" (Pressley & Levin, 1983, p. 139). Metamemory is explored in the present study for two reasons. Firstly, to clarify the role of knowledge about memory in patients with TBI and secondly, to question whether metamemory contributes to learning strategy deficits. Knowledge about memory means knowing about variables that affect memory ability, such as selecting and applying memory strategies, or organising a learning task. Metamemory as a concept is implied in the levels-of-processing and the contextual/constructionist models. Ornstein and Corsale (1979, cited in Cavanaugh & Perlmutter, 1982, p. 12) comment on the importance of knowledge in the levels-of-processing approach, claiming "the person's analysing structures serve as interpretive filters of incoming information", such that deeper processing is more likely when the information received is compatible with the person's existing knowledge structures. However, this can also be influenced by a subject's biases or by the use of mnemonic strategies. In this respect, Cavanaugh and Perlmutter (1982) note a possible limitation of the levels-of-processing approach is its emphasis on semantic knowledge effects alone. Rather, it is suggested the model should include such areas as "the individual's knowledge about the efficacy of various encoding strategies, the effects of different retrieval situations on retention, and the relationships between the two (p.12).

In contrast, the contextualist model asserts "that memory is not an exact copy of experience, but rather is the product of active interpretation of incoming stimuli (Cavanaugh & Perlmutter, 1982, p.13). Thus, incoming information is blended with previously acquired knowledge to produce a reconstructed memory trace at retrieval. Metamemory is important in this reconstruction process since it can only succeed if the individual is able to establish the context in which the new information should be interpreted and remembered. Thus, the context in which memory operates is a crucial determinant of memory performance.

In any memory experiment, there are four classes of variables that operate to establish the context:

1. Orienting tasks such as the type of activities and instructions.

2. Materials selected for the test procedure, depending on the sensory modality, type of stimuli, and the degree of organisation required.
3. Criterial tasks which distinguish between, for example, recall, recognition, or problem solving.
4. The subjects themselves, their abilities, knowledge, prior experience and levels of motivation (Cavanaugh & Perlmutter, 1982, p.13).
Each of these variables should be considered as well as the interactions amongst them. Bobrow (1975, cited in Cavanaugh & Perlmutter, 1982) also argued that knowledge of how our cognitive systems work is a critical dimension in learning. He proposed two kinds of self awareness: knowledge of facts and knowledge about process. Knowledge of facts involves analysing information and knowing whether some item(s) are missing, being able to rank the relative importance, interest, or usefulness of information. Knowledge about process includes being able to predict one's own capabilities, being able to choose the best strategy in various situations, and knowing how to allocate resources for the greatest benefit and efficiency.

3.5. THEORIES OF MEMORY

In the clinical setting two models of normal memory provide a widely accepted framework for understanding the dysfunctional memory problems associated with brain damage.

3.5.1. The Classical Triad: sensory, short term and long term memory.

The classical model proposed by Atkinson and Shiffrin (1968, 1971, cited in Reed, 1988) includes three components: a **short term sensory store**, a **short term memory (STM)** and a **long term memory (LTM)**. The short term sensory store identified by Sperling (1960, cited in Reed, 1988), preserves mainly visual information for just a few hundred milliseconds. Short term memory is thought of as a person's 'working memory'. It is limited in capacity, holding only about seven items (plus or minus two) (Miller, 1956). Information is lost after 15-30 seconds if it is not constantly attended or rehearsed - usually by verbal rehearsal. Interference rather than decay is given as the primary cause of forgetting (Reed, 1988).

Long term memory occurs when selected information is transferred from STM and becomes relatively permanent. It is that part of the brain which reminds us on Friday what we should do next Monday, or what we should have done last Monday (Reed, 1988, p.81). Long term memory is unlimited in its capacity, but to learn new information requires the application of learning strategies such as rehearsal or mnemonics. These techniques are well known to experimental psychologists, but have not been examined in relation to neurological impairment. Such memory problems may be attributed to a failure in the transfer of information from short-term to long-term store, and recovery is linked to an improvement in this transfer process.

Although it has enjoyed widespread recognition as a credible explanation of the way memory works, some researchers have questioned aspects of the LTM/STM temporal theory that do not stand up well under close scrutiny. For example, Wicklegren (1979) questioned how certain characteristics of the model (rate of information decay, capacity of the store and type of preferred encoding) were defined. Similarly, Sohlberg and Mateer (1989) queried the model's clinical utility in indicating the source of an individual's memory disturbance other than relating it to short or long term memory deficit. They see a need for a more comprehensive distinction between the initial intake, registration, or analysis of information. For example, where an individual is experiencing difficulty with short term recall, but retains that information well over the longer term, the clinician may want to consider the possibility of an attentional deficit or a language-processing deficit. In other instances, the problem may relate to retrieval or organisation of recall.

3.5.2. Levels-of-Processing Theory

An approach described as "more dynamic and multidimensional" views memory as "an information processing system conceptualised according to levels of processing" (Sohlberg and Mateer, 1989, p.139). Proposed by Craik and Lockhart (1972), the levels of processing model asserts that memory ability depends upon the way to-be-learned information is analysed during encoding. Material analysed <u>conceptually</u> involves deeper semantic processing and is usually retained and retrieved better than material analysed <u>perceptually</u> where only phonemic, or superficial processing is involved. Recovery of memory results from a regained capacity to engage in elaborative or deep analysis of information. This model emphasises such memory components as attention, encoding, storage, consolidation and retrieval:

1. **Attention** - incorporates the characteristics of alertness and arousal, as well as preparedness, vigilance, distractibility, and divided attention.
2. **Encoding** - the level at which an individual attends to material determines the likelihood of it being remembered later. Craik and Lockhart (1972) proposed that information is retrieved better when encoded at deeper (semantic), rather than shallow (phonemic) levels. Encoding also includes the use of strategies that enhance memory recall, such as cuing to features of the stimuli at the time of presentation by organising the information into chunks through clustering or categorising, or by active repetitive rehearsal (Craik & Watkins, 1973).
3. **Storage** - describes the transfer of information in STM to a more permanent store in the brain.
4. **Consolidation** - describes the integration of new information (memories) into existing cognitive schemata.
5. **Retrieval** - involves the search for, or the accurate and appropriate extraction of memory traces from storage (Sohlberg & Mateer, 1989).

The levels-of-processing theory proposes that material to be learned is coded in different ways. Initial processing involves the analysis of phonemic and structural features. Subsequent stages involve analysis of "pattern recognition" and "identification of meaning" (Reed, 1988, p.105). When an item is recognised, it may be further elaborated in other sensory modalities, for instance, a word, sight or smell depending on how a person associates that item with other similar stimuli from past experiences. Such analysis is said to proceed through a series of sensory states to deeper levels where patterns are recognised and semantic associations formed (Craik & Lockhart, 1972). At each stage of analysis, different memory traces are formed. These vary in their decay rate. When only the physical features of an item are processed, the memory trace is fleeting and decays quickly. When an item is identified recognised and named, the memory trace is more robust and may decay at a more intermediate rate. The strongest memory trace with the most resistance to decay occurs when a person elaborates the meaning of the stimulus. Thus, the levels-of-processing theory emphasises the way we analyse stimuli and the memory traces that occur at different levels of analysis (Craik & Lockhart, 1972).

In a critical review Baddeley (1978) cites three areas where the levels-of-processing theory of memory is considered deficient in operational definition. Firstly, the model fails to provide an independent measure of processing depth, a matter subsequently explored by Craik and Tulving (1975). Secondly, it failed to define levels within the divisions for phonemic and semantic coding, and thirdly, it includes further principles of compatibility and elaboration for which no independent measure is available. Baddeley (1978) also cites evidence to suggest that certain assumptions underpinning the levels model may be false. Notwithstanding such critiques, these models continue to influence contemporary amnesia research (O'Connor & Cermak, 1987, cited in Meier, Benton & Diller, 1987). According to Sohlberg and Mateer (1989, p.140) this information-processing theory that views memory as "a dynamic, multi-stage cognitive activity" is more useful than the passive storage-based model, when assessing memory disturbances associated with neurological damage or disease. Further, rather than an either or situation, Reed (1988) claims it is not unreasonable for the traditional theory (Atkinson & Shiffrin, 1968) and the levels-of-processing theory (Craik & Lockhart, 1972) to co-exist. In Reed's (1988) view, the latter model really serves best to describe memory traces operating in LTM and rather than seeking to deny the distinction between STM and LTM, a better approach might be to consider the two models as complementary.

3.6. FORGETTING

Psychologists have long asked whether the loss of information from STM is caused by interference or decay. Interference theory maintains that memory for particular information is disrupted by other distracting items or events between learning and recall. The trace decay theory suggests that forgetting simply occurs with the passage of time, particularly where one makes no attempt to rehearse the material. Thus, in memory disruption by interference, recall ability is determined by the number of interfering items, whereas in memory decay, recall ability is determined by the length of the retention interval (Reed, 1988).

Waugh and Norman (1965, cited in Reed, 1988) tested whether the loss of information from STM is caused by interference or decay and found that the number of interfering items had the greatest effect on retention. Other studies (Reitman, 1974, cited in Reed, 1988) found decay also occurs, but that the influence of decay on forgetting is substantially less than that of interference. Further, it is not only the number of interfering items that determine forgetting, but also the degree of similarity between the interfering and test items. The more similar items are, the more difficult it becomes to distinguish between test items and distracters. One positive outcome from these findings is that where information is lost through interference, it ought to be possible to implement structured learning techniques to minimise the loss. Such might not be the case if information was always lost by spontaneous decay (Reed, 1988).

3.6.1. Interference

Interference may be **proactive** or **retroactive**. The former occurs when events that are learned first interfere with those learned subsequently. In contrast, retroactive interference occurs when information learned after an event blocks that which came before. A study by Kepple and Underwood (1962, cited in Reed, 1988) demonstrated the effects of proactive interference. Although subjects performed very well initially, they deteriorated over subsequent trials, finding it difficult to distinguish between items presented on the current trial and those from earlier trials. Seeking ways to 'release' subjects from proactive interference, Wickens, Born and Allen (1963, cited in Reed, 1988) discovered that later items could be recalled better if they were made more distinctive from earlier items. Thus, a control group received items from the same class (words or numbers) across four trials and attempted to recall them, whilst the experimental group received three trials of words but on the fourth trial received items from another class (numbers). The experimental group showed a marked improvement in recall performance at the fourth trial since the interference effect was greatly reduced by introducing a distinctive new category.

Similarly, Gunter, Clifford and Berry (1980) showed subjects television news items across four trials. The control group viewed items from the same class (politics or sports) and attempted to recall them after a one-minute delay. The experimental group viewed items from the same class over the first three trials, but on the fourth trial were shown news items from the other class. The number of correct responses for the control group showed a steady decline over each of the four trials: trial 1, 87%, trial 2, 67%, trial 3, 55%, trial 4, 43%. In contrast, the recall performance of the experimental group showed a similar decline over the first three trials but gained considerably on the fourth: trial 1, 82%; trial 2, 67%; trial 3, 55%; trial 4, 74%. Thus, securing a release from proactive interference was attributed to the inclusion of a distinctive category and suggests that interference can be reduced by presenting information in an appropriate sequence. Thus, items that are likely to interfere with each other should not be presented together (Reed, 1988).

3.6.2. Rehearsal and the Serial Position Effect

In an experimental setting, the effectiveness of verbal rehearsal can be assessed most reliably by asking the subject to rehearse out loud. This allows the experimenter to count the times each item is rehearsed and to determine the extent to which recall of items is related to the number of rehearsals. Where more information is presented than can be held in STM, a serial position effect is usually evident whereby material presented first is recalled first, material presented last is recalled second, with material from the middle following last, if at all (Brooks, 1975).

Rundus (1971) designed an experimental task to test verbal rehearsal in this way. Presenting lists of twenty nouns to subjects one at a time at five second intervals, subjects were instructed to rehearse any word during the five second interval. After presentation of the complete list, subjects were instructed to recall the words in any order. Subjects' ability to recall each word depended upon its position in the list. Words at the beginning and end of the list were recalled better than words in the middle. The serial position effect is often portrayed as a U - shaped recall curve, a configuration regularly obtained in such experiments.

The term 'primacy effect' is used to describe better recall of words at the beginning of a list, and 'recency effect' for those better recalled at the end. Primacy effect refers to the high probability of recall for items at the beginning of a word list. But subjects are unlikely to successfully retain initial words in STM until test recall. The primacy effect is therefore considered to be a LTM phenomenon.

Initially there are few items in a word list to compete for subjects' attention and so they are rehearsed more effectively (Rundus, 1971). Such an explanation implies that the primacy effect should be eliminated if all words in a list are rehearsed equally often. Such was the finding of studies by Fischler, Rundus and Atkinson (1970, cited in Reed, 1988), and Rundus (1971). Sometimes the rehearsal of initial items is continued at the expense of items in the middle of the list. Since item recall is enhanced by rehearsal, the primacy effect is retained to rival recency.

In contrast, the number of rehearsals cannot be used to predict recency effect which refers to the high recall probability of items at the end of a word list. Nevertheless, subjects also do well in recalling words at the end even though they had less opportunity to rehearse these than the middle or former. This phenomenon is thought to occur because information heard last is still retrievable from STM since the interval between presentation and test recall is comparatively shorter. However, since information in STM decays rapidly if it is not rehearsed (Peterson & Peterson, 1959) the recency effect is prone to disruption by any interference between presentation and recall.

Brooks (1975) made an early distinction between short and long term memory in a study comparing the performance of TBI patients and normal controls. On a word list serial learning curve he found no significant difference in the STM portion represented by later word positions (recency effect), but rather more divergence between groups for the earlier word positions (primacy effect or LTM). Patients with TBI were significantly poorer in delayed recall performance suggesting an LTM deficit.

3.6.3. Amnesia

> *Amnesia is the loss of memory for reasons other than those that normally produce forgetting* (Wicklegren, 1979, p.45).

Memory loss (amnesia) is associated with such pathologies as head trauma, vascular disorders (strokes and ischemia), infections (encephalitis), tumours and degenerative diseases (dementias such as Alzheimer's and Korsakoff's disease). In addition, two medical treatments may contribute to memory loss: neurosurgery for treating various disease processes (for example, epilepsy) and electroconvulsive shock therapy (ECT) for depression (Kolb & Whishaw, 1990). Discussion of amnesia in the present study is focused solely on (TBI) and particularly, closed head injury (CHI).

The symptoms of amnesia include rapid forgetting, increased sensitivity to proactive interference, normal short-term storage, normal skill acquisition and responsiveness to retrieval cues (Hirst, 1982). Two types of amnesia are associated with the amnesic syndrome:

Retrograde Amnesia (RA) is commonly understood as memory loss for events immediately preceding the head injury. Its measurement can be uncertain or imprecise, particularly when estimates of RA duration are made some months or years post-injury. Neither is it always clear whether memory loss was absolute or partial, nor whether it includes events that occurred months or years before the injury (Kapur, 1988). Usually RA is quite brief, being counted in minutes or hours rather than days or weeks. In some cases, patients with mild head injury do not experience RA, reporting only an isolated period of post-traumatic amnesia (PTA). Wasterlain (1971, cited in Kapur, 1988) found that patients with RA of more than ten minutes tended to have more severe head injuries and cerebral contusion. Blomert and Sisler (1974, cited in Kapur, 1988) found that the duration of RA was always less than one minute where PTA was less than one hour. The condition known as shrinking RA was first reported by Russell (1935, cited in Kapur, 1988) who described a patient with CHI whose initial RA of five years shrank to just a few minutes over a ten week recovery period. The memories that are impaired in RA are not the weakest or the strongest, but rather the oldest and the most recent. Russell and Nathan (1946, cited in Wickelgren, 1979) found the recovery of RA occurred in chronological order with distant memory recovering first, followed by more recent memories. Finally, evidence suggests that shrinkage of RA often parallels recovery from PTA, which may resolve before RA, particularly in those few cases where significant RA remains as a permanent loss (Russell, 1971, cited in Kapur, 1988).

Post-Traumatic Amnesia (PTA) is described as one of the principal characteristics of CHI and refers to a period of memory loss that commonly occurs after CHI, even in those mild head injuries which do not include loss of consciousness (Levin, Papanicolaou & Eisenberg, 1984). The duration of PTA has been the subject of some debate. Symonds and Russell (1943, cited in Kapur, 1988, p.100) defined the period of PTA as ending "at the time from which the patient can give a clear and consecutive account of what was happening around him". This was to resolve confusion over whether "islands of memory" were indicators of the end of PTA although such islands of intact memory are now thought to reflect fluctuations of attention (Levin et al., 1984). In a more recent study of patients with CHI, Levin, O'Donnell and Grossman (1979, cited in Levin et al., 1984) designed the Galveston Orientation and Amnesia Test (GOAT) which aimed to monitor PTA and its termination by assessing orientation for time, place and patient's memory around the time of injury. Currently, the most widely accepted measure for determining termination of PTA is that of Gronwall and Wrightson (1980) who interviewed patients with mild head injury and proposed that PTA ended when a patient exhibited a return of continuous memory.

It can be misleading to quote 'typical' durations of PTA since this varies with the severity of CHI. Levin, Benton and Grossman (1982) report the total period of PTA will include some time in coma and a further period of impaired memory. In terms of outcome, patients with PTA of less than two weeks made good recoveries whereas those with longer PTA's suffered prolonged disability. Generally, PTA is more extensive than RA (Kapur, 1988).

Finally, some post-traumatic psychosis may be observed with PTA. Levin et al., (1984, p.247) note that anterograde amnesia is frequently accompanied by "lethargy, agitation, incoherent talkativeness, inappropriate behaviour, hallucinations, euphoria and fluctuations in autonomic functioning during the early stages of emergence from coma". Whitty and Zangwill (1977, cited in Kapur, 1988) observed a mild form of paramnesia or confabulation in some cases of PTA. Occasionally, such confabulation is associated with significant frontal lobe pathology following head injury, and is difficult to distinguish from general memory impairment.
Anterograde Amnesia (AA) refers to a loss of memory for events occurring after any of the pathologies mentioned above and is a major difficulty experienced with TBI.

3.7. MEMORY AND TBI

Both the frontal and temporal lobes of the brain are involved in memory - the temporal lobe in particular, and both are the areas most susceptible to the damaging effects of head injury. Consequently, most traumatically head injured patients complain of memory problems at some time (Lezak, 1983).

Memory problems may involve specific disabilities in sensory store registration, attention, tracking, short term memory learning and retrieval, the loss of anterograde and retrograde memories, or a condition in which the patient can store and retrieve information, but only with the help of response-directed questioning or cuing (Schacter & Crovitz, 1977). Other difficulties may involve the "regulation and control of activity, conceptual and problem solving behaviour" (Lezak, 1983, p.170), or may be due to slowed mentation, decreased initiation, or higher level attention problems. Morse and Montgomery (1992) describe three ways in which patients with TBI differ in their memory ability. Firstly, some remember material that is meaningful (for example, WMS-R: Logical Memory) better than items that are discrete (for example, the Auditory-Verbal Learning Test (AVLT; Rey, 1964; Lezak, 1983). Others do better the other way around. Secondly, some patients can remember simple material better than complex tasks (for example, WMS-R: Visual Reproductions versus the Rey Osterrieth Complex Figure). Thirdly, some patients perform better in learning tasks with feedback than with none (for example, Bushke Selective Reminding Test versus the AVLT).

Inferior performance on the AVLT shows up in several ways: a very slow learning curve, a plateau effect below expectation, mostly passive learning (dominant recency effect), erratic performance across trials, or a disorganised approach to learning. Other indicators of learning impairment may include perseveration within a trial, contamination errors - where words from different lists are confused, intrusion errors - including words from neither list, or interference - either proactive or retroactive. Patients with TBI of moderate severity frequently exhibit all or some of these (Morse & Montgomery, 1992).

3.8. CONCLUSION

In the context of verbal memory, experimental psychologists have found word lists a convenient medium for studying individual differences in memory ability. These may be paired-associate learning paradigms (Brown, Conover, Flores & Goodman, 1991) or studies of free recall learning involving discrete test items (Stoff and Eagle, 1971). The AVLT, an example of the latter, was chosen for the present study to examine the use of spontaneous memory strategies. Unlike control subjects who frequently use strategies to aid their memory recall, spontaneous strategies in patients with TBI (especially moderate to severe) are quite diminished or absent (Morse & Montgomery, 1992). A more comprehensive discussion of memory strategies and TBI is presented in the following chapter.

CHAPTER FOUR

STRATEGIES IN AUDITORY VERBAL LEARNING

> *It is generally agreed that learning and remembering depend on attention, use of an effective strategy, and the cognitive abilities needed to carry out that strategy*
>
> (Buschke, 1984, p. 33).

4.1. INTRODUCTION

Singer and Gerson (1979, p.216) define a strategy as a self initiated or externally imposed way of directing information, leading to decisions for purposeful behaviour. In information-processing terms, a strategy is thought to assist subjects in the formation of an organisational structure in which information can be stored and retrieved more efficiently. This process involves the learner in actively searching for contextual relationships between test items and information already stored in memory, so that new material can be combined and incorporated into newer and larger internal units.

Strategies may be of two types. The first group are well established, often habitual and automatic with the average person hardly aware that they using them (Baine 1986). Other strategies are specifically developed for a given task and involve conscious planning. In the context of the present study questions about both types of strategies were asked. Firstly, to what extent does automatic strategy use continue after head injury, and secondly, do patients with TBI have the requisite planning abilities to construct new learning strategies?

The aim of this chapter is to identify and examine the processing and encoding strategies most effective in learning verbal information. A review of the cognitive psychology and information-processing literature indicates research in this area has followed two general themes; that of identifying the type of processing that provides best retention, and an exploration of spontaneous strategy use by selected groups (Pressley, Heisel, McCormick & Nakamura, 1982, cited in McDaniel & Kearney, 1984).

4.2. EFFORTFUL AND AUTOMATIC PROCESSES IN MEMORY (ACTIVE AND PASSIVE LEARNING)

The ways in which people encode and retrieve information from memory must include some explanation of both deliberate strategy-based learning and learning that occurs automatically. Hasher and Zacks (1979) termed the former effortful processing which requires the expenditure of much attentional capacity and effort to aid memory. The latter are described as automatic processes, or incidental learning not consciously intended, for example, frequency, spatial and temporal information which is recorded automatically. (that is, how frequently different stimuli occur, where they occur in the environment, as well as when and for how long). In contrast to the use of deliberate learning strategies, people often find they can recall events they did not consciously set out to learn. Such unintentional learning is characterised by the absence of learning strategies (Reed, 1988). It was assumed that automatic or incidental learning processes would not be prominent in the present study since the discrete nature of the AVLT word lists and the requirement for free recall suggest the need for an effortful approach.

The present study extends the Hasher and Zacks (1979) notion of effortful processing by advancing the view that learning occurs in two ways - either passively or actively. Active learning involves the application of an external strategy technique to aid learning and implies the deliberate manipulation of test items to aid recall. Active strategies identified in the present study include conscious elaboration or grouping of words by association, mental imagery, and chunking. These are further described below.

Passive strategies reign where the external technique is absent and may result in inferior memory performance. The present study contends that both primacy and recency effects should be considered as passive rather than active strategies. Those subjects who demonstrate primacy or recency effects in free recall of word lists are passive learners. In a further departure from the Hasher and Zacks (1979) paradigm, the present study identifies rote rehearsal also as a passive strategy because of its link with primacy effects. Where a strong primacy effect is evident, subjects are usually engrossed in committing the first words heard to LTM through rote repetition. But this is not an active strategy, for whilst it requires much effort, the element of an external strategy technique is absent. Rather, concentration on rote repetition demands so much attentional capacity that it effectively stifles or prevents the individual from engaging in more effective active strategy techniques. In cognitive terms, the two approaches are mutually exclusive since they cannot both occur simultaneously. Rote rehearsal relies largely on structural or phonemic cues and is likely to result in inferior performance. Various studies (Pressley & Levin, 1977; Kimble, 1979; McDaniel and Kearney, 1984) support the notion that studying for meaning is more effective than rote rehearsal. Such deeper, elaborative processing has been shown to produce better recall than superficial or shallow processing (Kimble 1979).

Similarly, subjects who evidence a strong recency effect could be said to have undertaken very little processing. Their response on a free recall word list might represent nothing more than a reflexive recount of the last few words heard which are still retained in STM. By definition, such learning is passive since no attempt at active manipulation has occurred.

4.3. TYPES OF STRATEGIES

There are two broad categories: rehearsal and mnemonic strategies (Hasher & Zacks, 1979; Levin, 1989).

4.3.1. Rehearsal

Verbal Rehearsal is often thought of as a form of 'rote learning' because of the way information is repeated over and over until learned. This technique may sometimes be used when learning abstract, meaningless information for which coding or imaging strategies would be difficult. The process involves subjects maintaining a fixed number of items in STM which are rehearsed whenever subjects are not attending to a new item. The purpose of maintenance rehearsal is to retain information in STM long enough for it to be encoded and transferred into LTM. Unless encoding takes place, information in STM is remembered only as long as it is rehearsed and is lost when rehearsal ceases (Reed, 1988).

Rehearsal involves rote repetition of information to maintain it, either in STM (Craik & Watkins, 1973), or a rehearsal buffer (Craik & Lockhart, 1972) to enable immediate recall at any time during rehearsal. The process does not affect LTM. The means of repetition may be overt or covert, and tends to mimic the modality of the stimuli items. Thus, in the case of word lists, rehearsal is usually verbal. McDaniel and Kearney (1984) report several studies where subjects who consistently used less effective strategies such as rote repetition rehearsal subsequently performed worse on free recall than subjects who used an elaboration or semantic processing strategy.

Elaborative rehearsal is concerned not only with repetitive rehearsal, but also with deeper processing (Craik & Lockhart, 1972), forming associations and strengthening each memory trace. Since it is concerned with meaning, elaboration is thought to occur at the semantic level rather than by structural or phonemic associations (Anderson & Reder, 1979, cited in Reed, 1988). Processing information at deeper levels usually involves the creation of logical relationships between different components of the information. Using this strategy, new unfamiliar material is made more meaningful when it is associated with old, already learned information (Singer & Gerson, 1979). Using words from the AVLT, an example of elaboration might involve forming a sentence for the to-be-remembered words in a "farm" category. Thus, *the farmer wearing a hat in the garden saw a red nosed turkey down by the river.*

4.3.2. MNEMONICS

According to Websters New Collegiate Dictionary the term mnemonic is an adjective derived from the Greek words *mnemon* and *mnasthia* meaning respectively, "mindful" and "to remember". Mnemonic strategies are practical techniques used to improve the retrieval of information from memory. This may involve reorganising the information into a few conceptual categories, or linking the to-be-learned material with some common referent or shared association (Hasher & Zacks, 1979).

Within the mnemonic category, chunking, clustering and imagery feature as prominent strategies. Chunking is a subjectively devised strategy for overcoming the brevity of short term memory. It involves the effortful organising of a number of items into smaller chunks, say three chunks of four digits each, to improve the likelihood that all the digits will be remembered. A common example is a telephone number 3564455 which may be chunked in different ways without altering the order of the numbers. Typically this may involve pausing between the groups, for example, 356 (pause) 4455, or alternatively, using a different voice inflection or rhythm, for example, O eight hundred, eighty ninety eighty for 0800 809 080.

Clustering or categorising involves reorganising separate pieces of information into groups of similar or semantic categories. With the AVLT, for example, the words, *drum-curtain-bell-school-parent* may be grouped into a "school" category, whilst *garden-farmer-hat-nose-turkey-river* may constitute a "farm" category. Subjects need only remember the (fewer) category labels to prompt their recall of all the words. Clustering strategy is often revealed by the order of item recall. Typically, subjects who use this technique tend to remember the most words (Brown, et al., 1991). The distinction between different strategies is often subtle. Here, clustering made a category, whilst above, elaboration made a sentence.

Mental Imagery is a strategy used by subjects to form a hypothetical picture of to-be-learned items in their minds. This process is effortful (Hasher & Zacks, 1979) and works best with concrete words such as *hat* or *turkey* rather than abstract words such as *colour* or *honesty*. Performance may suffer where both concrete and abstract items are presented in the same trial. The rate of presentation of items is also important since slower rates allow more time for better images to be formed (Baine 1986).

Imagery mnemonic techniques have been found to enhance performance in such learning tasks as free recall (Jansen, 1976; Paivio, Yuille & Rogers, 1969; Richardson 1979, cited in Baine, 1986), serial recall (Pavio et al., cited in Baine, 1986), paired-associate learning (Paivio, Smythe & Yuille, 1968, Richardson, 1978, cited in Baine, 1986) and with recognition memory (Oliver, 1971, cited in Baine, 1986). Subjects who are explicitly instructed to use imagery strategies typically perform better than uninstructed subjects.

4.4. EVALUATION OF MNEMONIC STRATEGIES

An encoding strategy is really only effective if it serves to prompt other appropriate information. This also depends on the strength of the association between items in a word list. Where items belong to a similar category, it is likely that any one of several semantic strategies would be effective in aiding recall. On the other hand, where they cannot be easily categorised, a chunking strategy, may be more effective than a strategy aimed at elaboration of individual items (McDaniel and Kearney, 1984).

McDaniel and Kearney (1984) also found large individual differences in the kinds of strategies spontaneously employed within a group of learners, indicating that individuals rely on a variety of encoding strategies in their efforts to learn verbal material. They also suggest that different strategies may be used across as well as within verbal learning tasks. Further, one strategy may be used uniquely in one particular learning task, and other strategies particularly for other learning tasks. This is supported by Einstein, McDaniel and Battig (1978, cited in McDaniel and Kearney, 1984) who report that varying the encoding strategies for items within a list can enhance retention.

A further study examined learning patterns in normal subjects under three conditions. Firstly, subjects who had not been instructed to use an encoding strategy nevertheless spontaneously applied a variety of learning strategies on several learning tasks, and did so effectively. Secondly, in those groups where the experimenter did provide encoding strategies, some variation in their relative effectiveness was observed across different learning tasks. Thirdly, few subjects relied upon a rote rehearsal strategy, even though rote rehearsal has traditionally been viewed as an effective learning strategy (Norman, 1978, cited in McDaniel and Kearney, 1984).

Rohwer and Bean (1973) report comparable performances between uninstructed and instructed high school students in paired-associate sentence construction. Similarly, Pressley and Levin (1977) found ninety-four percent of a group of adolescents spontaneously used varying degrees of elaboration to learn a list of paired concrete nouns. One explanation for such differences could be that the application of encoding strategies may vary with different learning tasks. The efficacy of strategy use is illustrated by two classic studies, the first involving two groups of students. Woodrow (1927, cited in Baine, 1986) found a group of students who memorised lists for several hours performed no better than a control group who did not practice. A second group of students who received instructions in appropriate techniques for memorising lists performed much better after the same amount of study. The second study (Ericsson, Chase & Faloon, 1980, cited in Baine, 1986) reported the case of one college student of average intelligence and memory ability who increased his memory span from 7 to 79 digits after 230 hours of practice. The researchers concluded that given an appropriate strategy technique, retrieval method and practice, there were no limits to memory skills.

4.5. COMMON REASONS FOR POOR LEARNING

Baron (1978) identified three different reasons for poor learning:

1. Failure to use the appropriate strategy. Young children and the intellectually disabled, for example, will not spontaneously employ a rehearsal strategy in learning a list of words, unlike older children and adults. This can often be overcome by retraining techniques such as verbal instruction, modelling or shaping.
2. Inadequate proficiency. Different population groups differ in the proficiency with which they use a strategy. This can sometimes be overcome with repeated practice, but works better if the learner spontaneously discovers through practice, that the strategy works. Such overlearning may also lead to positive transfer of the strategy to other tasks, although it is unclear whether overlearning also leads to an increase in proficiency (Baron, 1978). Both proficiency and the probability of strategy use may be influenced by a third variable - the strength of a given strategy, where stronger strategies are more likely to transfer to new situations (Baron, 1978). If this is the case, it becomes necessary to identify and distinguish between those stronger and weaker strategies. Such a distinction is examined and elaborated in the present study.
3. Limited capacity. Groups differ in capacity in terms of the rate of rehearsal of items, the rate at which items decay in STM whilst other items are being rehearsed, speed of mental operations, ability to focus attention, and to deploy cognitive resources. Capacity limits cannot be overcome by psychological means, particularly in the case of TBI. Limited capacity may affect not only the level of skill evidenced, but also the ease of acquiring a strategy for the first time (Baron, 1978).

Overall, it seems more research is needed to clarify the relationship between intellectual ability, the effectiveness of learning strategies and task complexity. This issue is important in the context of TBI patients who tend to derive from lower socio-economic and less well educated populations. Understanding of the application of task appropriate encoding strategies has implications for normal education and for cognitive retraining and rehabilitation programmes. Where an appropriate match between processing strategy and learning task can be achieved, a successful outcome is more likely.

4.6. METAMEMORY AND STRATEGY USE

Is performance on a memory task related to, or dependent upon knowledge of memory strategies - a component of metamemory? Previous research has failed to find any consistent positive relationship between knowledge of appropriate strategies and their spontaneous use in memory tasks. Some subjects do spontaneously group items by category, yet do not identify this as a helpful memory strategy. Conversely, others who recognise the usefulness of a particular memory strategy, still do not apply it in test situations (Salatas & Flavell, 1976, cited in Waters, 1982).

Much of the research on metamemory has involved developmental studies with children. In one such study, Waters (1982) set out to evaluate the role of metamemory in normal children by examining relationships between memory, strategy use and recall performances. Believing strategy use might be a factor of age, her study included both younger children where elaborative strategies are first emerging, and older children where they are well established. Waters (1982) thought primary school children would be inconsistent, both in identifying a good memory strategy, and in the likelihood of their using such a strategy. In her study, children were presented with paired-associate word lists and, at the end of each interview, were asked to choose the type of strategy they used from amongst four choices: read the pairs carefully, rehearse pairs, and visual or verbal elaboration. The children were also asked to predict which, if any, of the strategies would be best for recall.

Waters (1982) found knowledge of appropriate memory strategies (metamemory) was positively related to strategy use which, in turn, was positively related to recall performance. The role of metamemory in memory development was found to change from the middle childhood years to adolescence. Knowledge of strategies led to the use of more effective elaboration techniques, especially where the test items favoured elaborative connections and where elaborative strategies were used, they proved more effective in improving memory. Whereas the use of elaboration strategies did not increase with age, they were more effectively employed by older pupils whose memory scores were better than those of younger pupils who also used elaboration. Waters (1982) claims this finding to be the first indication that memory development from childhood to adolescence involves both increases in spontaneous strategy use and in strategy effectiveness. As Flavell (1970, cited in Waters, 1982) notes, once a child is shown how to use a particular strategy, he or she can do as well as others already using that strategy.

4.7. MEMORY STRATEGIES IN TBI

Morse and Montgomery (1992) report that spontaneous strategies in patients with TBI (especially moderate to severe) are generally absent, a view shared by Godfrey and Knight (1987) who also found that patients with TBI do not spontaneously utilise memory enhancing strategies outside the immediate training context. In such instances, the usual memory remediation approach is to improve the patient's encoding by teaching a strategy that is not currently used, but which has been found effective in non-impaired subjects (Lawson & Rice, 1989). The principal area of concern is for those patients who are not able to employ spontaneous strategies. According to Morse and Montgomery (1992), this inability may be due to slowed mentation, decreased initiation, or higher level attention problems.

A further question is whether those patients not using spontaneous strategies would be able to do so with instruction and whether strategy use taught in a laboratory setting would subsequently generalise to other novel situations. Lawson and Rice (1989) examined this question in mentally disabled and learning disabled groups. With external prompts, subjects could be taught to improve their memory performance through strategy training, but once the external prompts were withdrawn, individual levels of performance typically declined to pre-strategy baseline levels. "It appeared to us, clinically, that the subjects were able to effectively utilise our techniques only when they were externally structured by the examiners"

(Kovner, Mattis, & Pass, 1985, cited in Lawson & Rice, 1989, p. 843). It was suggested that the presence of the experimenter and the training context constituted an external executive system which substituted for the patient's own executive deficit and which directed the use of the strategy. If this is the underlying strategy deficit problem, retraining efforts might be aimed at redeveloping the individual's executive system so that appropriate strategy applications can recur spontaneously. The ability to shift strategies appropriately across differing tasks is an indirect test of the adequacy of the executive system.

O'Donnell, Radtke, Leicht & Caesar (1988) compared the acquisition and learning performance of learning-disabled (LD), non-disabled and head injured (HI) young adults on the AVLT. Compared to non-disabled, the clinical groups had difficulty organising the word list items for effective retrieval. Group differences were found in the recency portion of the serial position curve but not in the primacy portion. This implies group differences in LTM but not STM. Following the interference trial, retention was poorer for the clinical groups than for the non-disabled. The finding of most relevance to the present study is that during retention, the non-disabled and less severely impaired clinical groups were able to maintain their strategies for organising the word lists, whereas the more disabled and head injured groups were not (O'Donnell et al., 1988). This finding is consistent with previous studies (Bauer, 1977, 1979; Brooks, 1975; Cermak, Goldberg, Cermak & Drake, 1980, cited in O'Donnell et al., 1988) that neither the learning-disabled nor head injured demonstrate impairment of STM. Rather, Levin, Grossman, Rose and Teasdale (1979) found that **patients with TBI often have so much difficulty with LTM that they rely excessively on STM even when they are asked to learn word lists that exceed the storage capacity of STM.**

Normally, young adults apply increasing organisation strategies across trials on a learning task and the extent of this organisation is related to their subsequent recall performance (Tulving & Donaldson, 1972, cited in O'Donnell et al., 1988). O'Donnell et al. (1988) found that group differences in recall on later trials reflected subjects' ability to organise words into consistent sets or clusters. This suggests that clinical groups (TBI or LD) do not rehearse the initial words as well as control groups, or, that they attempt to use a different rehearsal or organisation strategy. Of course there are exceptions. Lawson and Rice (1989) report the case of one patient with TBI who was unable to apply his own subjective organisation strategies on a word list task prior to strategy training, but who later learned to do so. In another case, Gianutsos and Gianutsos (1979) improved the performance of four closed head injury (CHI) patients using an elaboration strategy in a list learning study, albeit with some variation between patients.

Little work has been done on the extent and efficacy of active and passive learning in cases of TBI. One study (Levin & Goldstein, 1986) tested CHI patients and controls under four word list conditions to assess their use of semantic knowledge in learning tasks. They found that CHI patients performed best when words were presented in a clustered rather than unclustered format, unlike control subjects who consistently organised related words according to category. The authors concluded that this low level of spontaneous organisation amongst patients with severe CHI demonstrated a passive approach to learning. A further study which compared TBI and control group performance showed that whereas both used the same cognitive processes at times, the unimpaired controls performed more quickly, smoothly, and efficiently and tended to process less information. Their performance became automatic with the development of skill, and the necessary control processes were invoked without much conscious effort (O'Donnell et al., 1988).

Can patients with TBI tell whether an item is stored in LTM or do they realise it is not stored, but give up because they do not know what to do to get it stored there? The study of metamemory may be relevant in cases of TBI where an inactive learner's basic problem is that he or she is less prone to apply the memory strategies that normal populations spontaneously use. Some important questions arise with TBI patients. For example, is it possible that deficits in metamemory arising from head injury contribute to poor memory? Does a lack of conscious knowledge about what is stored in memory, and a lack of awareness about strategies to aid memory lead to poor performance on memory tests?

Differences in skill level between TBI patients and normal controls may be better understood using the analogy of beginners and advanced performers, where TBI patients are likened to beginners and normal controls to advanced performers. A beginning learner may not be able to distinguish between relevant or irrelevant situational cues and may, therefore, process several cues individually. This results in an increased STM load and a commensurate reduced capacity to process additional information which might be present or useful, since little organisation of the material can take place. The beginner might be unaware of how to use appropriate control processes and, consequently, may offer only erratic recall of selected items from the wealth of information, since each of the cues to be processed has to be retrieved separately (Singer & Gerson, 1979). In contrast, an advanced performer would be more likely to "abstract the commonality amongst items" and employ an appropriate strategy for processing information. Since common items would be processed as one unit, more capacity becomes available to accommodate further stimuli (Singer & Gerson, 1979, p. 223). In a sense then, the quality of the encoding cues determines how efficiently those cues are retrieved (Tulving & Thomson, 1973).

It appears that little is known about metamemory in head injury populations at the present time. Future studies should examine reported awareness of memory strategies, as well as knowledge about when and in what tasks certain strategies are most appropriately applied. Further studies are also needed on the direction of causation in memory - metamemory connections. For example, is the poor serial learning curve of TBI patients a cause or an effect of their metamemory deficiency in serial recall, or are both the result of some other factor(s)? It is these questions that the present study addresses.

Based on the studies of Baine (1986) a number of questions can be raised in considering the criteria for selecting and evaluating mnemonic strategies.

1. Does the strategy enhance long or short term retention? For example, simple rehearsal does not lead to long term storage.
2. How much time and effort is required in training to master the strategy? Are patients with TBI able to undertake sufficient practice or will the amount of work decrease motivation to apply the strategy?
3. What level of cognitive functioning is needed to acquire the strategy? Is the technique suitable for patients with TBI?
4. Is the strategy consistent with the learner's style or abilities?
5. In what manner is the information recalled? Are there restraints with regard to speed of recall and the type of information that is available?

6. Does the strategy interfere with comprehension?
7. Does application of the strategy interfere with concurrent learning methods?
8. Does application of the strategy interfere with other learned information? Does the strategy lead to proactive or retroactive inhibition?
9. Does the strategy promote a primary associative link between the recall demand cue, and the first link in the mnemonic chain of storage and recall?
10. Does the strategy generalise to a variety of situations?
11. Does the manner in which information is encoded facilitate the integration of related information? (Baine, 1986, p.98-99).

4.8. CONCLUSION

It is against this theoretical and experimental background of cognitive psychology that the present study examined the use of memory strategies by survivors of TBI and controls on a verbal learning procedure such as the AVLT. The present study identified three strategy groups amongst learner populations. Some individuals use no learning strategies at all, some use only passive strategies and others use active strategy techniques. The next two chapters describe the measure and method adopted with explanations of subject recruitment, the instrument employed and the procedure followed.

CHAPTER FIVE

THE PRESENT STUDY

5.1. OBJECTIVES

The present study examined traumatic brain injury, verbal memory and, in particular, the application of spontaneous strategies to aid performance in such verbal tasks. It sought to discover the characteristics of subjects who spontaneously used some form of memory strategy and whether that strategy was associated with superior test scores over successive trials. The Rey Auditory Verbal Learning Test (AVLT; Rey, 1964; Lezak, 1983) was chosen for the present study because of its widespread acceptance and utility as an effective and valid measure of a range of verbal learning and memory functions, but specifically because it is a useful instrument for indicating how subjects organise and process information as evidenced by their performance on the serial learning curve, the order in which they recall words and the existence of primacy and recency effects. As a free-recall measure it was more appropriate for the examination of **spontaneous** strategy use amongst subjects than verbal memory tests involving cued-recall.

Clinicians have observed large individual differences in the performance of patients with TBI on such memory measures and question whether low test scores are entirely attributable to organic tissue damage, or whether other deficits in cognitive functioning are involved, such as the ability to organise and process to-be-learned information. Comparisons were made between patients with TBI and control subjects across a range of variables. Subjects aged between fifteen and fifty were selected for either group. The age restriction aimed to control for the effects of developmental confounds in younger individuals and memory decline due to aging amongst older persons. General variables for which individual data was gathered included subjects' occupation, years of education, ethnicity, and handedness. In cases of TBI, information about the number and severity of previous concussions head injuries and length of associated retrograde and post-traumatic amnesias was gathered. Time elapsed between TBI and testing was also noted.

An unexpected finding in the present study was the number of individuals with TBI who had volunteered as control subjects. Of the 98 controls tested, 39 (40%) had to be eliminated since their history of previous concussive episodes was a major contaminant. Further research would clarify the extent of the disproportionately high number of individuals with past TBI, who are currently unemployed or in prison and who have not received neuropsychological evaluation.

5.2. HYPOTHESES

The following hypotheses were predicted:

Hypothesis 1

That control subjects will score significantly higher than TBI subjects on the AVLT.

Hypothesis 2

That TBI subjects will adopt fewer active strategies than controls.

Hypothesis 3

That for both TBI and control groups, subjects using active strategies for learning will perform significantly better on the AVLT than those using passive strategies who, in turn, will perform significantly better than those using no strategies at all.

Hypothesis 4

That control subjects adopting active strategies will perform significantly better than TBI subjects using active strategies on the AVLT.

Hypothesis 5

That the smallest difference in performance between TBI and control groups will be found between those using active strategies.

Hypothesis 6

That TBI subjects will be more susceptible to interference effects than controls.

Hypothesis 7

That there is no difference between TBI and control subjects in the number of intruding words.

Hypothesis 8

That there is no difference between TBI and control subjects in the number of words repeated.

Hypothesis 9

That the order of words recalled on post-interference trials 6 and 7 will reflect the degree of learning, i.e. subjects with lower AVLT scores will demonstrate rote learning which is associated with primacy effects, which is a passive strategy and a LTM phenomenon commonly compromised following TBI.

CHAPTER SIX

METHOD

6.1. CHARACTERISTICS OF PARTICIPANTS

One hundred and forty TBI patients and fifty-nine control subjects participated in the present study. In the TBI group, 72.3 % were male and 27.7 % female. Ages ranged from 16 to 68 (Mean 31.20, Median 29.5, SD 10.04). Such gender and age ratios are consistent with the findings of earlier studies (Gronwall, Wrightson & Waddell, 1990) which describe typical survivors of TBI as young adult males. In contrast, the control group was more homogeneous, being comprised of 54.2 % males and 45.8 % females. The control group ages were similar to those in the TBI group, ranging from 17 to 66 (Mean 32.86, Median 31.00, SD 10.43).

Ethnicity was predominantly European across both groups (TBI, 85%; controls, 74.6%) followed by Maori (TBI, 19%; controls, 22%). A negligible number of subjects in both groups were of Polynesian or Asian extraction.

Right-handed subjects (TBI, 81.4%; controls, 89.8%) predominated over left-handed subjects (TBI, 17.1%; controls, 10.2%). However, it is noted that a greater proportion of TBI subjects were left-handed and this is discussed further in chapter 8.

The mean number of years of post-primary education was 3.70 (SD 2.03) for the TBI group and 4.76 (SD 2.11) for the controls. Statistical analysis by *t*-test indicated a significant difference, ($t(233) = -1.31$, $p < .05$).

Subjects were categorised according to their occupational background (see Table 6.1). In the case of TBI subjects this was determined as at the time of injury. In both groups, the majority of subjects were found in the trade and labouring categories (TBI, 68.6%; controls, 59.3%).

Traumatic brain injury subjects were categorised according to the type of accident they suffered (see Table 6.2). Motor vehicle accidents (67.5%) accounted for most injuries, followed by falls (15.1%) which also included work related falls. In the majority of cases, the head injuries sustained (see Table 6.2) involved deceleration forces (86.4%) with acceleration accounting for 12.9 percent. Only one case of compression was reported.

The severity of TBI was classified as either mild, moderate or severe as measured by the duration of post-traumatic amnesia (PTA). Periods of PTA greater than 24 hours are associated with severe TBI, those lasting between one and twenty four hours represent moderate TBI, whilst PTA of less than one hour is considered to be a mild head injury (Morse & Montgomery, 1992). Severe TBI was indicated in 53.6 percent of subjects with 22.1 percent moderate and 24.3 percent mild head injuries.

Other factors which could have affected memory performance in TBI subjects were presence of a history of multiple concussions (27.85%), drug and/or alcohol abuse (6%), and a combination of both these factors (9%).

Demographic characteristics of the two hundred subjects who participated in the present study are summarised in Table 6.1.

TABLE 6.1.
Characteristics of Group Participants

	TBI		CONTROLS	
SEX	*(N)*	*(%)*	*(N)*	*(%)*
Male	101	72.3	32	54.2
Female	39	27.7	27	45.8
TOTAL	140		59	
AGE	*Years*		*Years*	
Mean	31.20		32.86	
Median	29.50		31.00	
SD	10.04		10.43	
Range	16-68		17-66	
ETHNICITY	*(N)*	*(%)*	*(N)*	*(%)*
European	119	85.0	44	74.6
Maori	19	13.6	13	22.0
Polynesian/Asian	2	1.4	2	1.4
HANDEDNESS	*(N)*	*(%)*	*(N)*	*(%)*
Right Handed	114	81.4	53	89.8
Left Handed	24	17.1	6	10.2
Ambidextrous	2	1.4	-	-
EDUCATION (at time of testing)	*Years*		*Years*	
Mean post-primary	3.70		4.76	
Median post-primary	3.00		5.00	
SD	2.03		2.11	
OCCUPATION (at time of injury)	*(N)*	*(%)*	*(N)*	*(%)*
Beneficiary	10	7.1	8	13.6
Student	21	15.0	5	8.5
Labourer	41	29.3	14	23.7
Tradesperson	55	39.3	21	35.6
Professional	13	9.3	11	18.6

TABLE 6.2.

Characteristics of Traumatic Brain Injury

TYPE OF ACCIDENT	*(N)*	*(%)*
Motor Vehicle	95	67.5
Fall	23	15.1
Assault	11	7.2
Work (excluding falls)	6	3.9
Sports	5	3.3
TOTAL	140	
TYPE OF HEAD INJURY		
Deceleration	121	86.4
Acceleration	18	12.9
Compression	1	0.7
TOTAL	140	
SEVERITY OF HEAD INJURY		
Mild	34	24.3
Moderate	31	22.1
Severe	75	53.6
TOTAL	140	
OTHER MEMORY CONTAMINANTS		
Multiple Concussions	39	27.85
Alcohol/Drugs	8	0.06
Both the above combined	12	0.09
Unknown	81	57.85
TOTAL	140	

Further analysis was performed using Chi-square statistics to examine the association of TBI severity with the period between date of accident and date of assessment (see Table 7.2). There was no significant association $\chi^2(10, N = 140) = 18.29$. $p<.05$.

TABLE 6.3.

Number and severity of TBI subjects in each interval period between date of accident and date of assessment.

MONTHS

	1-5	6-9	10-15	16-24	25-60	60+		
SEVERITY							**TOTAL (%)**	
Mild	9	3	6	4	7	5	34	24.3
Moderate	4	1	5	4	13	4	31	22.1
Severe	10	2	5	10	20	28	75	53.6
TOTAL	23	6	16	18	40	37	140	
(%)	16.4	4.3	11.4	12.9	28.6	26.4		

The experimental subjects were one hundred and forty one (141) (male n=102 and female n=39) clients with TBI referred to the Psychology Clinic at Massey University for neuropsychological assessment over a two year period. Most had been referred by the Accident Compensation Corporation having earlier received neurological diagnoses of brain injury involving either unilateral lesions to the left or right hemispheres, or diffuse bilateral cerebral damage. The majority of patients presented with head injuries in the moderate to severe range, although some with mild head injuries were seen where the patient reported ongoing cognitive difficulties. To the extent that it excludes many mild cases, the head injury population in the present study is not representative of all who suffer TBI in the population at large.

Control subjects comprised four groups. Nine (9) were randomly drawn from the population at large, eighteen (18) were volunteer extra-mural students at Massey University, twenty seven (27) were volunteers recruited from the New Zealand Employment Service in Palmerston North and forty one (41) volunteered from Manawatu Prison to make a total of 95. The control groups were chosen to provide an approximate match on such demographic variables as age, sex, ethnicity, laterality, level of education and occupation. All were screened for any prior history of head injury, a process which required 39 (40%) of those interviewed to be eliminated from the study.

Patients with TBI attending the Massey University Psychology Clinic were either invited to participate in the present study, or permission was sought from them to have their AVLT scores included as research data. Student controls were recruited on campus after the researchers outlined the purpose of the present study during class. Controls from the local Employment Centre and Manawatu Prison were recruited after posters about the research were displayed. All were invited to participate on a purely voluntary basis without any coercion by the researchers, or staff at the respective agencies.

6.2. RESEARCH SETTING

The present study was conducted throughout 1993 under supervision from the Psychology Department at Massey University, Palmerston North, New Zealand. All patients with TBI were tested in the neuropsychology room of the Psychology Clinic at Massey University. All volunteer students were tested in an interview room within the Psychology department at Massey University and volunteers from the community at large were tested either in an interview room located on the premises, or an interview room within the Psychology department at Massey University.

6.3. RESEARCHERS

The present study constitutes a Masters thesis and was jointly conducted by Brad Grimmer - M.A. student and Dr. Janet Leathem, Director of the Psychology Clinic, who acted as supervisor. The researchers and various clinicians working in the Psychology clinic were involved in administering the AVLT to patients.

6.4. ETHICAL ISSUES

The nature of the study was explained to all participants prior to their inclusion in the subject pool and only those giving their informed consent were included. Participants were given a written information sheet and invited to telephone the researchers should they have any questions, either before or after their participation. All participants' rights to confidentiality and anonymity were explained and scrupulously respected. All records were number coded and seen only by the researchers. All patient files have been routinely stored in a locked filing cabinet at the Clinic. It is not possible to identify any individual in any reports that are prepared from the study. The master file will be destroyed upon completion of the research. Participants were advised that they could refuse to answer any particular question or to withdraw from the study at any time, without prejudice.

6.5. RESEARCH DESIGN

Any neuropsychological study should select subject groups to avoid prejudicing the eventual findings. The type of subjects included can limit a study's external validity since the results obtained will only pertain to the subject population and may not generalise to a wider population. Given the relativity of all psychological measurement, efforts to test the cognitive deficits of head injured patients involves comparing their performance against some standard - typically, a normal control group (Levin, Grafman & Eisenberg, 1987).

The present study employed an ex post facto quasi-analytic design, since the experimental subjects were, in a sense, pre-selected on the basis of a particular characteristic they exhibit, that is their head injury (Dunham, 1988). The problem with such a design is the inability to assign subjects randomly to the different treatment conditions, with the result that a range of confounding variables may be introduced between experimental subjects and controls. One way to eliminate the confounding variables is to match the subjects in the two groups so that they are equivalent in all characteristics except that of head injury.

To achieve this, it was necessary to define and isolate a convenient group in the wider population whose demographic characteristics bear some resemblance to those of the head injured. Based on tentative profiles of head injured populations, it was anticipated that such a group would be found amongst those currently unemployed and prison inmates. An attempt was also made to recruit a further random group of subjects from the population at large to minimise the risk of convenience sampling procedures biasing the sample in the direction of finding memory disturbance for reasons other than head injury. However, this was only partially successful due to difficulties experienced in the availability of such people.

6.6. THE MEASURE

6.6.1. Introduction

The Rey Auditory-Verbal Learning Test (AVLT) (Lezak, 1983; Rey, 1964) is a word learning list which assesses a wide range of verbal learning and memory functions. The reliability, validity and clinical utility of the AVLT are now well established across a range of diagnostic groups (Mungas, 1983; Rosenberg, Ryan & Prifitera, 1984; Ryan, Geisser, Randall & Georgemiller, 1986) as well as between neurologic and non-neurologic subjects (Powell, Cripe & Dodrill, 1991). These authors found the AVLT an effective measure of brain impairment because of the complex memory functions it could assess. In particular, the AVLT scores obtained on trials 1-5 are said to reflect "the combined functioning of a wide cross-section of neurobehavioural mechanisms, including arousal, motivation, attention, concentration, auditory perception, verbal comprehension, immediate verbal memory span, short term verbal memory storage and retrieval, and progressive serial learning abilities" (Powell et al., 1991, p.248). In another study, the AVLT is described as "assessing the relative integrity of encoding and retrieval processes by providing a comparison between recall and recognition performances, a learning curve, assessment of primacy, recency and interference effects, and a comparison of immediate versus delayed recall" (Forrester & Geffen, 1991, p. 345). Thus, there is a high possibility that any randomly selected brain dysfunction will include impairment in one or more of the above abilities.

6.6.2. Outcomes

Clinicians find the AVLT effective in these important areas for evaluating contradictory performance or in assessing whether the memory deficit is functional or organic. As well as differentiating between various clinical groups of patients with neurologic and psychiatric disorders, the AVLT is sensitive to lateralised brain damage and memory-impaired versus non-memory-impaired neurologic patients. Differences have also been found between (a) "amnesics and head trauma patients versus (b) schizophrenics, non-psychotic psychiatric patients and attention deficit patients, as well as depressed versus alcoholic patients" (Wiens, McMinn & Crossen, 1988, p.68). Query & Berger (1980) found AVLT differentiated between age differences for acute head trauma, stroke patients, education and intelligence quotients. Ryan, Rosenberg and Mittenberg (1984) found a positive correlation between AVLT and verbal subscales of the Wechsler Memory Scale, when comparing a diverse sample of neurologic and psychiatric subjects.

Generally, Pellegrino & Battig, (1974) report that the subjective-organisation measures used by normal subjects can affect their recall capacity, and Mungas (1983) proposed that such measures might also be implicated in assessing memory disorders amongst other diagnostic groups. Using the AVLT, Mungas (1983) examined the processes subjects use to organise memory and obtained mixed results in several diagnostic samples. His five subject groups included amnesics (AM), head trauma victims (HT), schizophrenics (SC), attention deficit disorder patients (ADD), and non-psychotic psychiatric patients (NP). The groups and trials main effects and their interaction were all statistically significant at the .001 level. Pairwise comparisons of group means showed no significant difference on Trial 1 (Mungas, 1983, p.850). Measures of group differences in numbers of words lost from Trial 5 to the delayed-recall trial showed significant losses for both the AM and HT groups ($ps<.01$), but not for the other groups. (Mungas, 1983). Thus, the performance of amnesic and head trauma subjects became progressively worse than the other groups as the number of trials increased, suggesting an impaired learning ability.

A review of the literature reveals that much of the emphasis of current research with the AVLT has focused on establishing normative data amongst various populations (Wiens, McMinn & Crossen, 1988; Bleecker, Bolla-Wilson, Agnew & Meyers, 1988; Geffen, Moar, O'Hanlon, Clark & Geffen, 1990), rather than examining aspects of subjective organisation such as how the use of strategies might affect performance. This is an area requiring further experimental research which the present study addresses. The objective is a more extensive description and evaluation of the effectiveness of the strategies used by patients with TBI in responding to a commonly used verbal memory test such as the AVLT.

In summary, the AVLT is a multi-trial, free recall instrument which measures short term memory, verbal learning, post interference recall and recognition. In the assessment of verbal learning and short-term memory, this measure is increasingly acknowledged as a useful, brief and valid measure for supplementing the mental status examination (Rosenberg, Ryan & Prifitera, 1984). Further, the cognitive psychology theoretical base upon which it is founded adds weight to that utility.

6.6.3. AVLT Administration

This procedure consists of 15 common nouns, in one of three lists (see Appendix A), which were read aloud at one second intervals for five consecutive trials. Before presenting the word list for trial 1 the examiner gave the following instructions:

> *I am going to read a list of words. Listen carefully, for when I stop you are to say back as many words as you can remember. It doesn't matter in what order you repeat them. Just try to remember as many as you can* (Lezak, 1983, p.423).

Following each presentation of list A, subjects were instructed to recall in any order as many words as possible from that list and these were recorded by the examiner in the order recalled. The examiner would respond if asked whether a word had been repeated but did not volunteer information otherwise, lest it interfered with the subject's performance or became a distraction. When the subject had exhausted all the words able to be recalled, the examiner gave a second set of instructions before re-reading the list of words:

> *Now I am going to read the same list again, and once again when I stop I want you to tell me as many words as you can remember, including words you said the first time. It doesn't matter in what order you say them. Just say as many words as you can remember whether or not you said them before* (Lezak, 1983, p.423).

The word list and recall instructions were repeated after each trial without revealing the number of correct responses. After the fifth learning trial, a second list of 15 words (List B) was administered as a distraction task (trial I). The examiner made the following comment:

> *Now I am going to read a second list of words. This time again, you are to say back as many words of this second list as you can remember. Again, the order in which you say the words does not matter. Just try to remember as many as you can* (Lezak, 1983, p.423).

This was immediately followed by a post-distraction recall trial of the original words from List A, without presentation (trial 6). The final procedure was to test for long term memory with one last recall of List A after a 30 minute delay (trial 7).
See note appended to page 55

6.7. PROCEDURE

Each interview commenced with an explanation about the nature of the research (see Appendix B) and subjects were invited to sign a consent form (see Appendix C). Demographic questions were asked of subjects (see Appendix D) as well as questions about any previous concussive episodes they had experienced.

The AVLT was then administered according to the Lezak (1983) format (see Appendix A). Both the standard form (list A) and alternate form (list C) (Ryan, Geisser, Randall & Georgemiller, 1986) were used for repeat administrations on some patients with TBI, or where the possibility of collusion amongst certain controls was suspected. In the interval between trials 6 and 7, other neuropsychological measures were administered to utilise the time productively. Tests chosen for this purpose included:

1. The Rey Complex Figure (Rey, 1941).
2. The Stroop Color-Word Test (Dodrill, 1978).
3. The Twenty Questions (Laine & Butters, 1982).

These measures were selected firstly because they fitted nicely into the available time, secondly, they are measures which might be used in a typical neuropsychological examination, and thirdly, they are not verbal memory measures which might otherwise have contaminated verbal memory results. At the conclusion of test administration, subjects were given an opportunity to ask further questions or to discuss their performance. Appropriate feedback was provided and at the conclusion of each interview, subjects were thanked for their participation in the present study.

Overall analysis of the data obtained for all subjects is presented in the following chapter. The verbal memory scores of each group were compared quantitatively for statistically significant differences, and qualitatively, to evaluate the cognitive processes used by each. Main effects were compared within as well as between groups.

Following trial 7, subjects were asked:

When you were trying to learn the list, were you using any special method to help you?

The subjects response was recorded in full, then those who said that they used a method, were asked:

What was/were the method/s you used?

When the records were scored, responses were coded into one of three groups: no strategy; passive strategy (primacy and recency only); a combination of passive and active with active strategies predominating later.

CHAPTER SEVEN

RESULTS

7.1. Hypothesis 1

That control subjects will score significantly higher than TBI subjects on the AVLT.

Statistical analysis (*t*-test) was performed to determine the extent of any difference in performance between the two groups. The results as set out in Table 7.1. indicate that there was a significant difference between TBI and control groups across all trials, with the difference increasing steadily across successive trials 1 to 5 becoming most marked at post-interference recall trials 6 and 7. At all times the TBI group scored below the control group. The two groups showed similar shaped learning curves however, as shown in Figure 7:1.

TABLE 7.1.

T test comparison of AVLT Mean Scores by Trial by Group

Trial	TBI		Controls		
	M	SD	M	SD	t value
1.	5.59	1.88	6.83	1.94	4.17*
2.	7.44	2.44	9.33	2.66	4.70*
3.	8.96	2.91	11.20	2.67	5.26*
4.	9.76	2.94	12.36	2.36	6.58*
5.	10.16	2.87	12.86	2.15	7.30*
Interf	4.85	1.94	6.25	2.06	4.46*
6.	7.70	3.76	11.34	2.92	7.37*
7.	5.35	4.76	11.46	3.16	10.63*

* $p < .001$

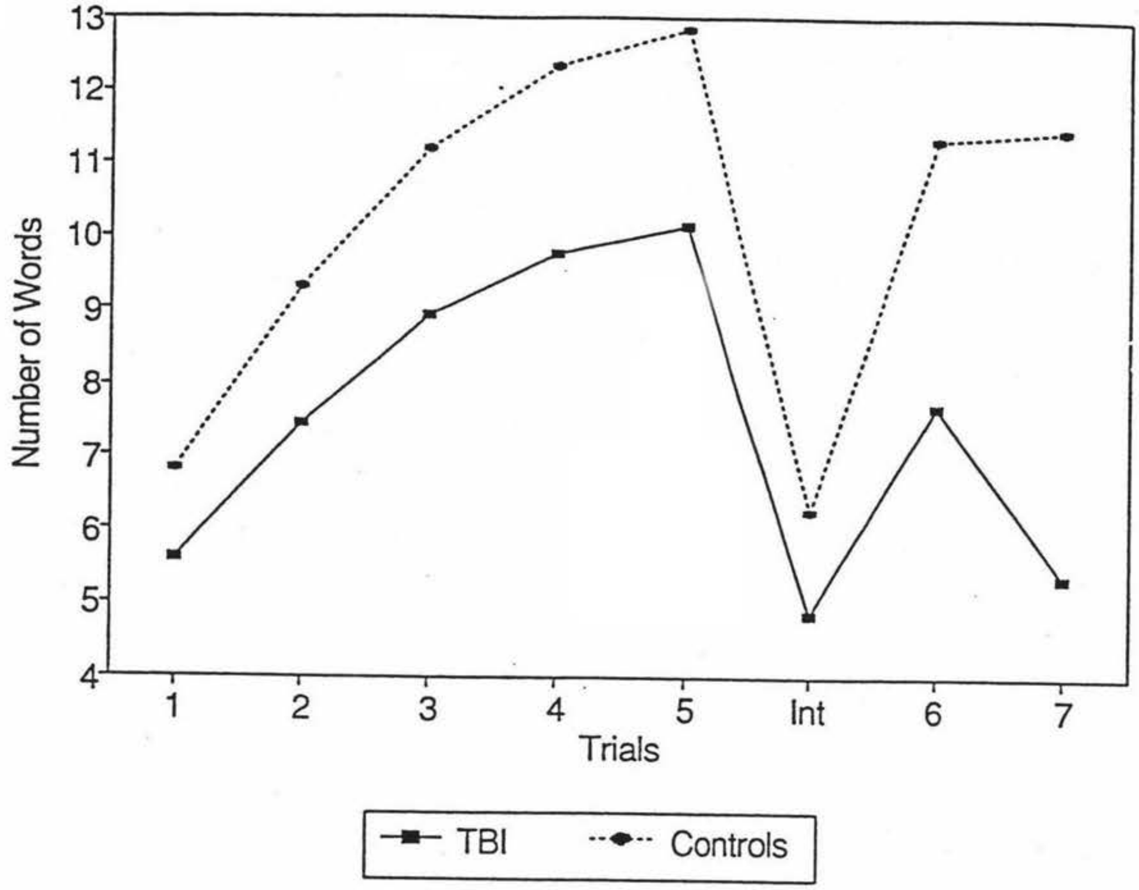


Figure 7:1 Mean Scores over all AVLT trials for TBI and Control groups.

The greatest difference between the two groups is seen on recall trials 6 and 7. On trial 6, the two groups showed a similar pattern of decrease compared to trial 5. At delayed recall (trial 7) however, the shape of the learning curves changed dramatically. Whereas the control group appeared to lose no more material than their trial 6 performance scores (+.12) and almost doubled their trial 1 score (trial 1=6.83, trial 7=11.46), the TBI group at trial 7, dropped markedly and recalled <u>less</u> than they did at trial 1 (trial 1=5.59; trial 7=5.35). The least difference between the groups is seen on trial 1 (M diff=1.35), followed by scores on interference trial (M diff=1.40). Both groups scored slightly lower on the interference trial compared to their trial 1 scores. The important questions that arise from the results for hypothesis 1 are, why do the TBI group fall so dramatically on trial 7 and why does the control group consistently outperform the TBI group, even on trial 1 measuring short term memory?

7.2. Hypothesis 2

That TBI subjects will adopt fewer active strategies than controls.

To test this hypothesis, subjects were classified into three strategy groups according to the type of spontaneous strategies evidenced during administration of the AVLT. The first group included those who used no strategies at all. The second group comprised those who employed only passive strategies which, in the present study, were defined as primacy and recency effects and rote learning. The third group included those who adopted conscious or elaborative strategies, collectively grouped as active strategies. Particular strategies identified in this latter group included grouping words by association, forming mental images, and chunking as described in chapter four. Where subjects used a mix of strategies the dominant strategy was selected, for example a subject beginning with rote learning as the preferred strategy (passive), but who changed to use predominantly active strategies later was included in the active strategy group only.

Frequencies and percentages of TBI and control groups using respective strategies are shown on Table 7:2 and the same data is shown in more diagrammatic form in Figure 7:2.

TABLE 7.2.

Number and Percentage of Participants in each Strategy Group

	TBI		Controls	
	N	%	*N*	%
No strategy	36	25.9	4	6.8
Passive strategy	89	63.5	32	54.2
Active strategy	15	10.6	23	39.0
Total	140		59	

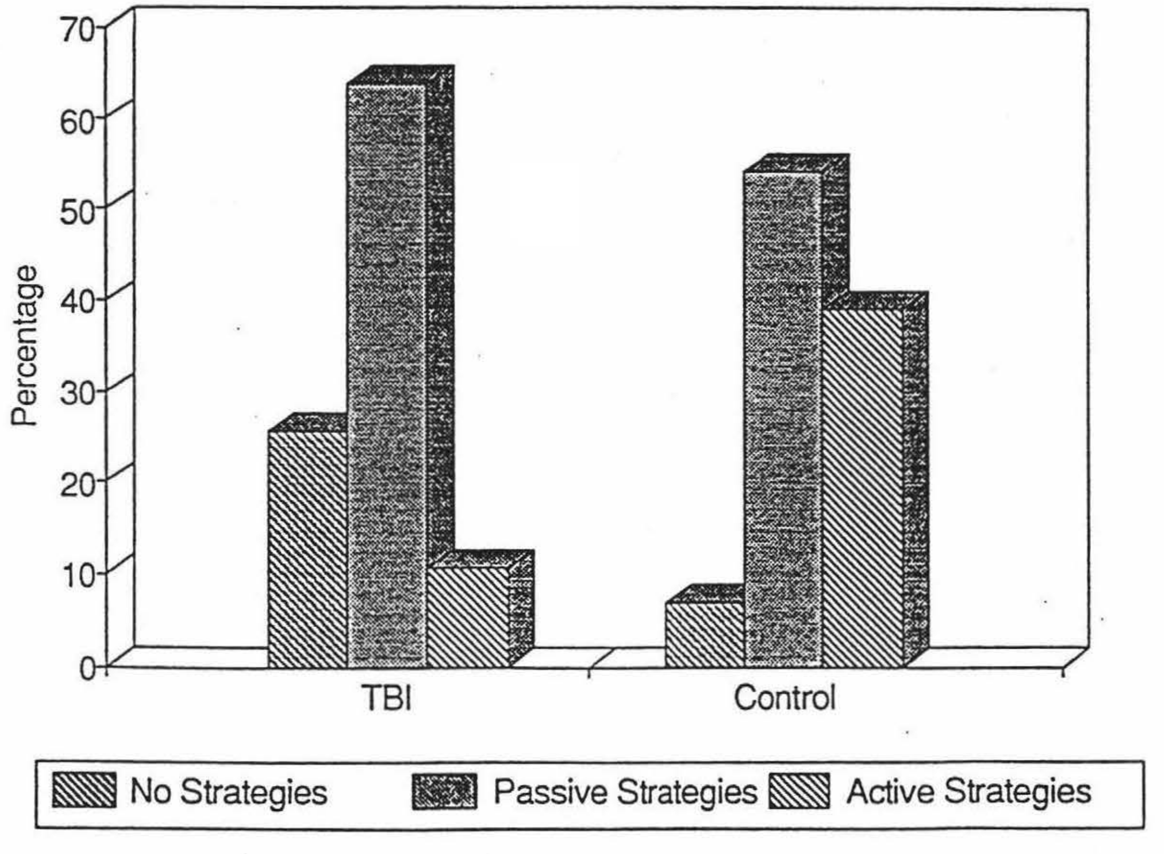


Figure 7:2. Percentage of TBI and Control subjects in each Strategy Group.

Clearly, passive strategies were utilised most by both groups. The biggest differences were between the no strategies and active groups. Only 6.8% of the control group used no strategy at all compared to 25.9% of the TBI group. Of the TBI group only 10.6% used active strategies compared to 39% of the control group. Thus the hypothesis that the control group would use more active strategies than the TBI group was confirmed. The results presented with hypothesis 3, clarify these differences. Further comparisons were made between strategy groups and the severity of TBI, as presented in Table 7.2.a.

TABLE 7.2.a.

Number and Severity of TBI subjects in each Strategy group.

	None	Passive	Active	Total in severity groups	%
SEVERITY					
Mild	6	23	5	34	24.3
Moderate	7	22	2	31	22.1
Severe	23	44	8	75	53.6
Total	36	89	15		
% in strategy groups	25.9	63.5	10.6		

Overall, there were 75 (53.6%) severe TBI subjects compared with 31 (22.1%) moderate and 34 (24.3) mild cases. Whereas the majority of all TBI subjects employed passive strategies (63.5%), twice as many <u>severe</u> TBI subjects adopted either passive or no strategies compared to their moderate and mild counterparts. However, the finding that 8 (5.7%) severe cases employed active strategies compared with 2 (1.4%) moderate and 5 (3.6%) mild cases contradicts any suggestion that fewer severe TBI subjects would use active strategies.

7.3. Hypothesis 3

That for both TBI and control groups, subjects using active strategies for learning will perform significantly better on the AVLT than those using passive strategies who, in turn, will perform significantly better than those using no strategies at all.

Results for this hypothesis were viewed in two ways.

1. Within group analysis of variances (ANOVAs) were conducted to compare performances of the three strategy groups on each trial of the AVLT. As indicated in Table 7.3, significant main effects were found across all trials in both TBI and control groups.

TABLE 7.3.

Means, Standard Deviation and Within Group Analysis of Variance by Strategy Group by Trial, for TBI and control subjects.

	No Strategy		Passive Strategy		Active Strategy		F Value
TBI	*N* = 36		*N* = 90		*N* = 15		
1	4.52	1.76	5.73	1.65	7.27	1.98	14.33*
2	6.19	2.49	7.57	2.08	9.73	2.58	13.49*
3	7.22	2.99	9.22	2.55	11.60	2.32	15.68*
4	7.58	2.61	10.18	2.65	12.47	1.88	22.42*
5	8.22	2.71	10.48	2.59	12.93	1.67	20.05*
Interference	3.81	1.65	5.04	1.80	6.20	2.37	10.46*
6	5.75	3.29	7.94	3.44	10.87	4.27	11.94*
7	3.22	3.84	5.67	4.63	8.60	5.44	8.03*
Controls	*N* = 4		*N* = 32		*N* = 23		
1	5.25	1.50	6.41	1.77	7.70	1.92	4.98*
2	8.25	2.22	8.84	2.46	10.22	2.84	2.23*
3	9.25	2.06	10.38	2.67	12.70	2.03	7.62*
4	9.25	2.63	11.63	2.31	13.91	1.08	14.71*
5	9.75	2.36	12.44	2.06	14.00	1.44	10.69*
Interference	5.00	.82	5.69	1.86	7.26	2.11	5.39*
6	8.00	3.92	10.84	3.91	12.61	2.17	6.21*
7	7.00	5.09	10.84	2.93	13.09	1.93	10.03*

* $p < .001$

A visual representation of group means is provided in Figure 7:3 and shows clearly the difference in performance between sub-groups.

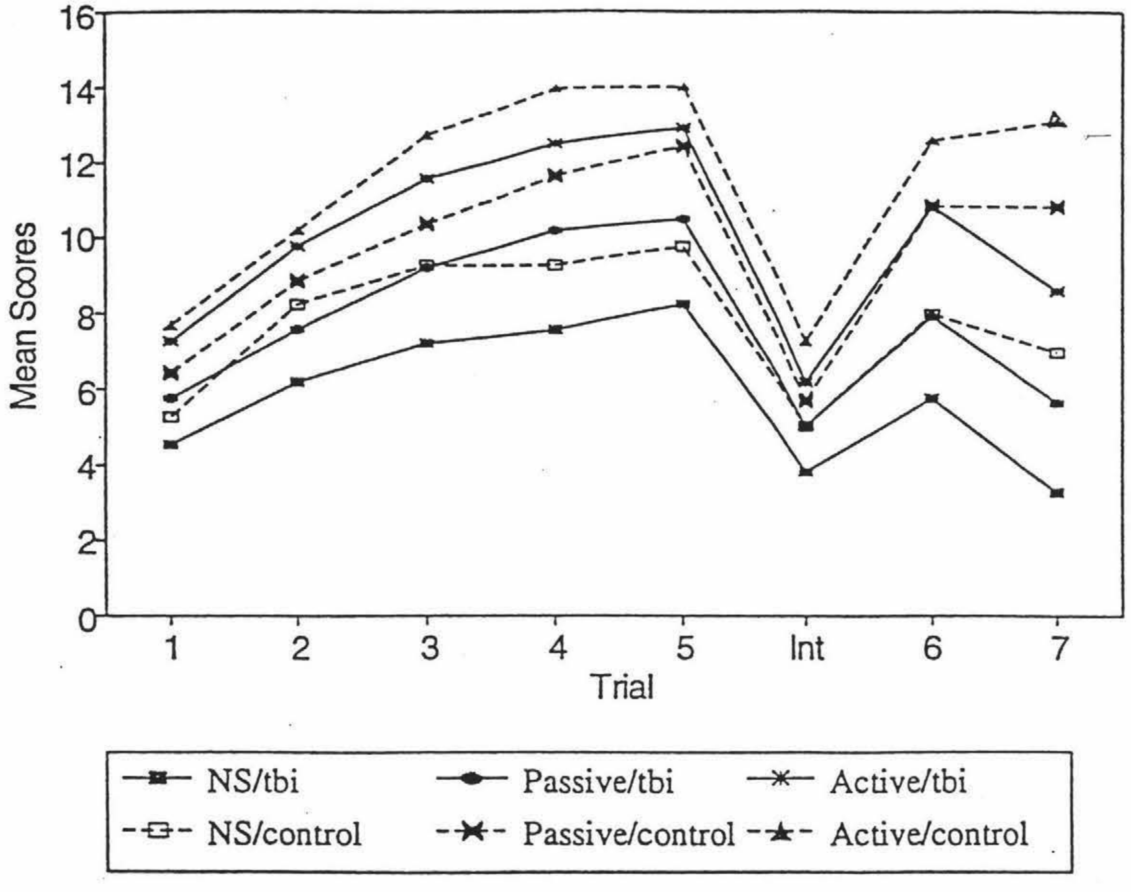


Figure 7:3 Mean Scores over all AVLT trials for TBI and control groups for different strategy groups

The shapes of the learning curves for TBI and control groups were similar (Table 7.3. and Figure 7:3) with TBI scores consistently lower across trials. There were also no major differences between TBI and control groups in the rate of learning or the shape of learning curves when different strategy groups were compared until trial 7, where steady learning with increasing separation was shown for both groups. Both TBI and control groups dropped markedly as expected between trials 5 and 6 as they were presented with the interference list. The greatest difference between trial 5 and interference occurred for both TBI and control passive groups. As has been stated, the learning pattern changes dramatically at trial 7. Although the TBI group using active strategies gained higher scores than the other two strategy groups, they still dropped by the same proportion as the other TBI groups at trial 7. In comparison, only the no strategy control group dropped between trials 6 and 7, and then less proportionately than any of the TBI groups. These differences are examined in more detail in hypotheses 5 and 6.

A flattening of the learning curves of both TBI and control groups using no strategies occurred between trials 3 and 4, but these were not significant. Control groups consistently scored higher than TBI groups when the same strategy was used. However, when results between strategy groups were compared, the TBI group using passive strategies performed better than the control group using no strategy at all. Similarly the TBI group using active strategies performed better than the control group using passive strategies. Thus, there was a two-way hierarchical advantage - control over TBI, active over passive and no strategy groups.

The questions that arise from examination of hypothesis 4 are, why does the active strategy TBI group score drop at trial 7, when the active strategy control group mean score continues to rise and is there any explanation of the apparent flattening of the learning curve in trials 3 and 4 for the no strategy groups?

2. In addition to ANOVAs, pairwise comparisons were conducted using the Scheffe test to examine comparisons between each strategy-group pair (see Table 7.4). In this way the difference between the scores is highlighted. The Scheffe adjustment was chosen as the most "conservative and flexible of the popular methods" (Tabachnick & Fidell, 1989, p.53) for computing critical F whilst maintaining the error rate at a particular value regardless of the number of comparisons made (Keppel, 1982). In the TBI group, subjects adopting passive strategies consistently performed significantly better across all trials than those using no strategies. Similarly, subjects adopting active strategies performed significantly

better than those using passive strategies on learning trials 1-5 and post-interference recall (trial 6).

In the control group, subjects adopting passive strategies performed significantly better on trials 5 and 7 than those using no strategies. Similarly, subjects adopting active strategies performed significantly better than those using passive strategies on learning trials 1 3 4 5 and delayed recall (trial 7). (see Table 7.4).

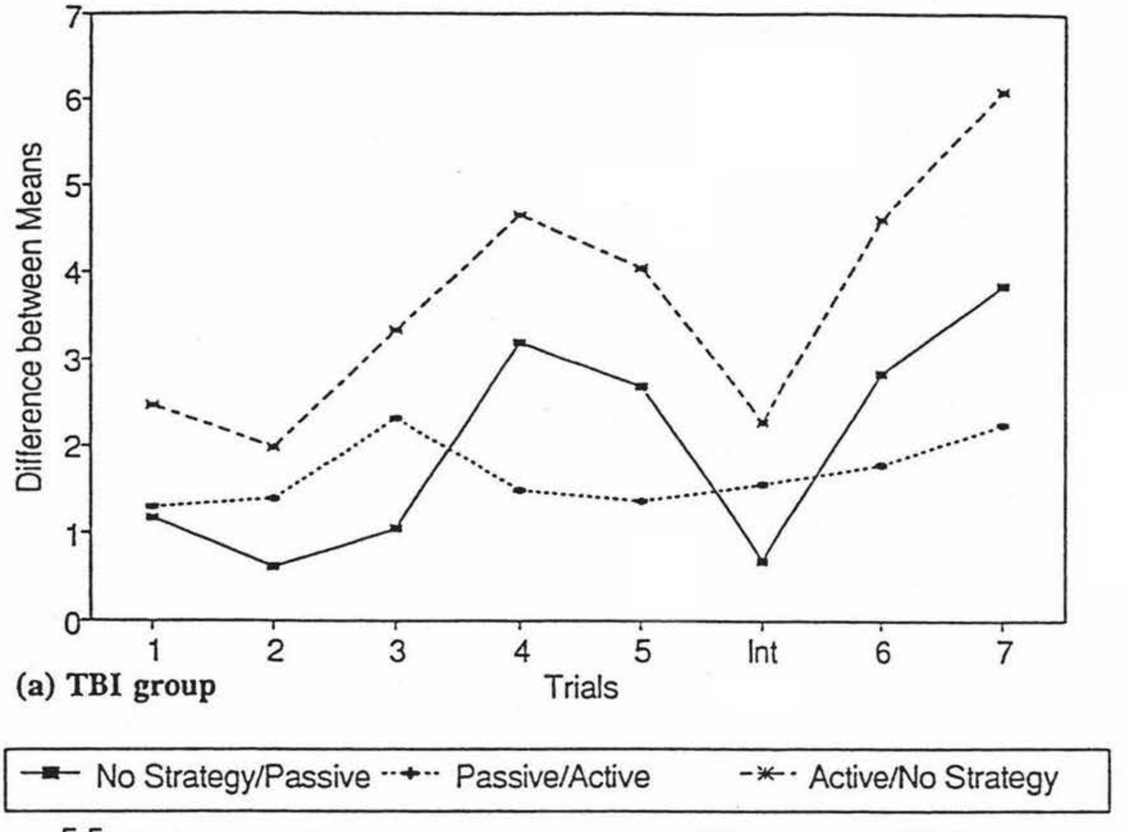
TABLE 7.4.

Comparison of Group Pairwise differences between Means: No strategy/passive, passive/active and active/no strategy for TBI and Control Groups

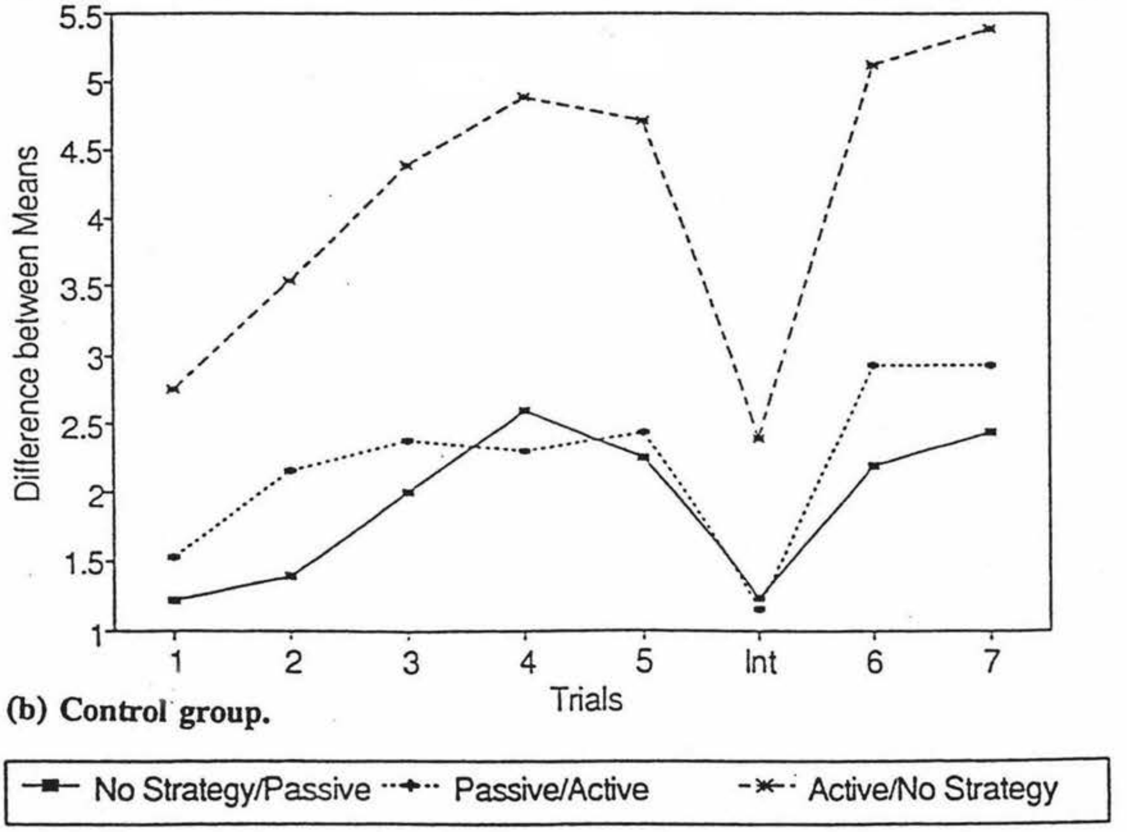
Trial	No Strategy/ Passive	Passive/ Active	Active/ No Strategy
TBI	*N* = 36	*N* = 90	*N* = 15
1	1.21 *	1.54 *	2.75 *
2	1.38 *	2.16 *	3.54 *
3	2.00 *	2.38 *	4.38 *
4	2.60 *	2.29 *	4.89 *
5	2.26 *	2.45 *	4.71 *
Interference	1.23 *	1.16 *	2.39 *
6	2.19 *	2.93 *	5.12 *
7	2.45 *	2.93 *	5.38 *
Controls	*N* = 4	*N* = 32	*N* = 23
1	1.16	1.29 *	2.45 *
2	1.59	.38	1.97 *
3	1.03 *	2.32 *	3.35 *
4	3.19 *	1.47 *	4.66 *
5	2.69 *	1.36 *	4.05 *
Interference	.69	1.57 *	2.26 *
6	2.84 *	1.77 *	4.61 *
7	3.84 *	2.25 *	6.09 *

$p < .05$

The differences between the groups using different strategies is shown diagrammatically in Figure 7:4.



(a) TBI group



(b) Control group.

Figure 7:4 Comparison of differences between Means for Strategy Groups for (a) TBI group and (b) Control group.

Comparison of the figures in Figure 7:4 suggests that for the TBI group there were similar differences when no strategy was compared to passive and when passive was compared to active across trials. There was more variability between the strategy groups on later than earlier trials. In the control group, differences were more pronounced when no strategy versus passive and passive versus active were compared. This appeared to be in part due to a slight droop in the learning curve of the passive learning group. At trial 7, there is a marked difference between the no strategy and passive groups, with the control passive group performing at a higher level whilst the TBI passive group remained below their no strategy counterparts.

7.4. Hypothesis 4

That control subjects adopting active strategies will perform significantly better than TBI subjects using active strategies on the AVLT

A MANOVA procedure was attempted to test the significance of the Between-group means which were presented in Table 7.3. and Figure 7:3. While the comparison between no strategy TBI and control groups was not meaningful due to the disparity in group numbers, there was a highly significant difference between TBI and control groups using active strategies. This was most noticeable on trial 7 where the TBI group decreased on trial 6 scores, in contrast to the control group which increased markedly. This hypothesis is confirmed.

7.5. Hypothesis 5

That the smallest difference in performance between TBI and control groups will be found between those using active strategies.

As presented in Table 7.5, this hypothesis was supported on all AVLT trials except on the interference trial and on trial 7, (marked by asterisk on Table 7.5). This data is presented in diagrammatic form in Figure 7:5. Passive groups showed the least difference at interference (0.65) and the greatest difference at trial 7. The TBI group using passive strategies performed markedly below the scores of the control group using passive strategies. This discrepancy has already been highlighted in earlier results sections. There is limited support for this hypothesis, but the hypothesis is rejected at trial 7.

TABLE 7.5.
Difference between TBI & Control groups on each Strategy Group over all AVLT trials

Trial	No Strategy	Passive Strategy	Active Strategy
1	.73	.68	.43
2	2.06	1.27	.49
3	2.03	1.16	1.10
4	1.67	1.45	1.44
5	1.53	1.96	1.07
Interference	1.19	.65 *	1.06
6	2.25	2.90	1.74
7	3.78 *	5.17	4.49

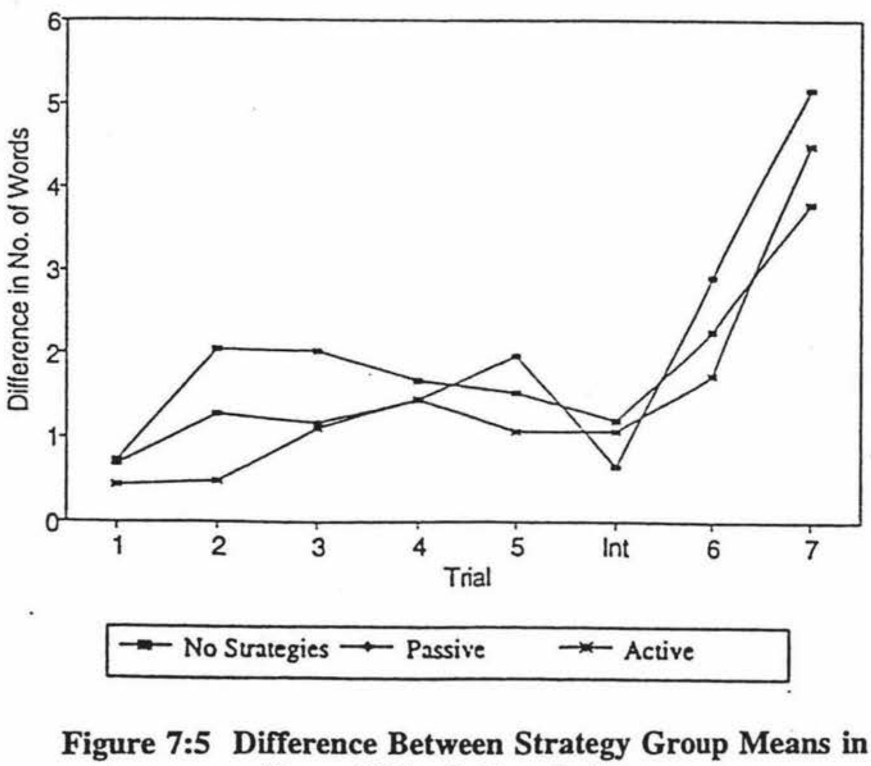


Figure 7:5 Difference Between Strategy Group Means in Number of Correct Words Recalled.

7.6. Hypothesis 6

That TBI subjects will be more susceptible to interference effects than controls.

This hypothesis was not supported as evidenced in Table 7.6. and Figure 7:6. In the present study, interference was said to have occurred where recall from either of Lists A or B differed by three or more words. Controls (71.2) demonstrated more interference effects than TBI subjects (54.6) which seems contradictory, given that control groups consistently gained higher scores than TBI subjects.

TABLE 7.6.

Number and Percentage of subjects in each Interference Category.

Group	No Interference		Proactive Interference		Retroactive Interference	
	N	%	*N*	%	*N*	%
TBI (*N* = 140)	64	45.4	74	52.5	3	2.1
Control (*N* = 59)	17	28.8	33	56.0	9	15.2

Questions that arise from the examination of hypothesis 6 results are, why are TBI groups less susceptible to interference, yet still perform less well than the control groups and why is proactive interference so much more apparent than retroactive interference.

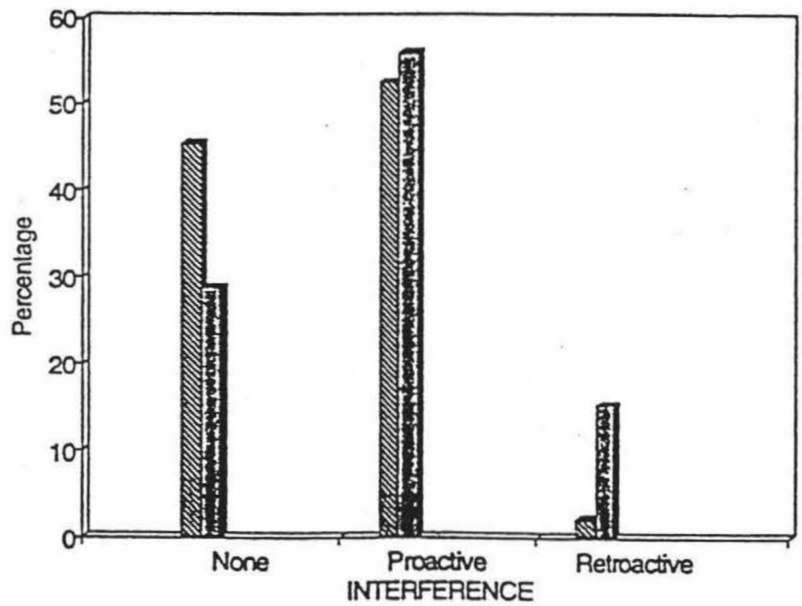


Figure 7:6 Comparison of the percentage and types of interference demonstrated by TBI and control groups.

7.7. Hypothesis 7

That there is no difference between TBI and control subjects in the number of intrusion errors.

Intruding words are those found in neither list which are introduced externally by subjects. For example, "teacher" was recalled frequently although it appears on neither of the presented AVLT lists, but may have been introduced because of its association with "school" in List A. The number and percentage of such errors for each group is presented in Table 7.7. Overall, more TBI subjects made intrusion errors than controls, a finding which supports a poorer self-monitoring ability amongst this group. Some individuals guessed more (ie. over several trials, often with the same intruding word). At the lower end, one intrusion was recorded by 41.5% of controls compared to 29.3% of TBI subjects, whereas six (7.3%) TBI subjects and two (3.8%) controls recorded nine intruding words, the highest number. More commonly, subjects from both groups recorded between one and three outside words. It is difficult to draw meaningful comparisons between the groups but there appears to be moderate support for this hypothesis.

TABLE 7.7.

Difference in Number of Intruding Words over all AVLT trials for TBI and Control Groups.

Number of Intruding Words	TBI	(%)	Controls	(%)
1	24	(29.3)	22	(41.5)
2	19	(23.2)	8	(15.1)
3	11	(13.4)	5	(9.4)
4	6	(7.3)	3	(5.7)
5	6	(7.3)	6	(11.3)
6	4	(4.9)	3	(5.7)
7	3	(3.7)	1	(1.9)
8	3	(3.7)	3	(5.7)
9	6	(7.3)	2	(3.8)
Total	82		53	

Similarly, the number and percentage of contamination errors recorded by each group are presented in Table 7.7.a. These occur when subjects confuse words from each list. For example, subjects might confuse "turkey" in List A with "bird" in List B. There was no significant difference between groups, since very similar percentages of TBI and control subjects recorded 1,2,3, or 7 contamination errors.

TABLE 7.7.a.

Difference in Number of Contaminating Words over all AVLT trials for TBI and Control Groups.

Number of Contaminating Words	TBI	(%)	Controls	(%)
1	19	(70.4)	9	(69.2)
2	5	(18.5)	3	(23.1)
3	2	(7.4)	1	(7.7)
7	1	(3.7)	-	-
Total	27		13	

7.8. Hypothesis 8

That there is no difference between TBI and control subjects in the number of words repeated.

The number and percentage of words repeated by subjects in each group is presented in Table 7.8. As with intrusive words, some individuals appeared more likely to repeat words (sometimes the same word over several trials, others several different words). Not all subjects repeated words, but amongst those who did, the most common pattern in both groups was repetition of between one and five words. Overall, more controls exhibited repetition, for example, 33.8% of controls repeated one word compared with 17.6% of TBI subjects. Either the latter group could not remember sufficiently well to engage in repetition, or they chose to adopt a cautious approach. It was again impossible to draw meaningful comparisons between the groups. There is only moderate support for hypothesis 8.

TABLE 7.8.

Number of Words Repeated by each Group

Number of Words Repeated	TBI	(%)	Controls	(%)
1	18	(17.6)	24	(33.8)
2	18	(17.6)	13	(18.3)
3	12	(11.8)	8	(11.3)
4	10	(9.8)	7	(9.9)
5	17	(16.7)	3	(4.2)
6	5	(4.9)	4	(5.6)
7	4	(3.9)	3	(4.2)
8	7	(6.9)	5	(7.0)
9	2	(2.0)	-	-
10	1	(1.0)	1	(1.4)
11	3	(2.9)	1	(1.4)
12	2	(2.0)	1	(1.4)
15	1	(1.0)	-	-
16	2	(2.0)	-	-

7.9 Hypothesis 9

That the order of words recalled across AVLT trials will reflect different learning techniques between TBI and control groups, i.e. subjects with lower AVLT scores will demonstrate rote learning which is associated with primacy effects, which is a passive strategy and a LTM phenomenon commonly compromised following TBI.

There were no clear strategies apparent when the overall order of words was reviewed. Both groups consistently recalled the first word, last word, second word, second to last word, third word followed by words moving towards the centre of the list <u>until</u> trials 6 and 7 when both groups recalled the first six words, and the last words reverted much closer to their serial position. Aside from passive strategies, active strategies were evident in the linking of some words, for example, "farmer" and "garden" (words 10 & 8). Further, the words "farmer" and "turkey", were recalled more frequently than expected from their serial order. The rank order of words recalled is shown in Table 7.9. with gaps indicating those instances where TBI subjects were unable to recall certain words.

TABLE 7.9.

Rank Order of Words Recalled Across all AVLT trials.

List Order	Word	Group	Rank Order over Trials 1	2	3	4	5	6	7
1	Drum	TBI	1	1	1	1	1	1	1
		Control	1	1	1	1	1	1	1
2	Curtain	TBI	3	3	3	3	3	2	2
		Control	3	3	3	3	3	3	2
3	Bell	TBI	5	5	5	5	6	3	3
		Control	6	6	5	5	2	2	4
4	Coffee	TBI	10	9	7	8	8	5	4
		Control	6	7	8	7	7	4	4
5	School	TBI	9	7	8	9	9	4	5
		Control	7	9	9	9	8	5	5
6	Parent	TBI	11	10	12	10	10	6	6
		Control	11	10	12	11	10	6	6
7	Moon	TBI			11	12	15	14	11
		Control	15	12	15	14	13	7	13
8	Garden	TBI		12		13	14	15	12
		Control	12	14	13	12	15	8	7
9	Hat	TBI	12			11	13	10	10
		Control	14	13	14	15	14	11	14
10	Farmer	TBI	8	8	10	15	11	9	8
		Control	8	11	10	13	12	9	8
11	Nose	TBI	7	11	6	14	12	8	13
		Control	10	8	11	10	11	10	12
12	Turkey	TBI	6	6	9	7	7	7	14
		Control	9	5	7	8	9	12	11
13	Colour	TBI				6	7	13	15
		Control	13	15	5	6	6	14	9
14	House	TBI	4	4	4	4	4	12	7
		Control	4	4	4	4	4	15	15
15	River	TBI	2	2	2	2	2	11	9
		Control	2	2	2	2	2	13	10

7.10. Summary of Results

The TBI and control groups demonstrated learning curves of similar shapes, but the TBI group performed consistently below the control group regardless of the strategy method used until trial 7. At this point, active strategy use enhanced the performances of the control group, but appeared to have little effect other than to maintain the advantage gained by using active strategies over trials 1-5. The two groups were closest in their performances whilst using active strategies, but as stated this disappeared at trial 7 where the greatest difference occurred between the TBI active and control active groups.

Passive strategies were used predominantly by both groups, although the tendency was for controls to use more effective strategies, whereas TBI subjects chose less effective strategies or none at all. The TBI group was less susceptible to interference than controls, less likely to use intrusive words and slightly less likely to repeat words. Intrusions and repetitions most frequently involved between one and five words.

Examination of the order of word recall revealed that primacy effect is the predominant component, is a passive strategy and is so strong that it obscured other associations. There appear to be few consistent word associations with individuals more likely to link words in ways that were individually meaningful. At delayed recall, recency was rarely used by either group whilst primacy was extended. These results do not appear to be confounded by education. Questions raised by these findings will be addressed in the following chapter.

CHAPTER EIGHT

DISCUSSION

The purpose of the present study was to examine verbal memory amongst patients with TBI, particularly their use of learning strategies to aid memory performance. The idea for this study arose from the clinical observation that memory performance varied enormously amongst TBI patients and raised questions as to whether this was entirely attributable to organic tissue damage, or whether other deficits in cognitive functioning were involved. Thus, the present study differs from earlier AVLT research in that emphasis was placed on the way subjects organised and processed to-be-learned information as well as their overall test scores.

Epidemiology

This chapter begins with a description of the participants in the present study. The TBI related findings were similar to those reported by Morse and Montgomery (1992) except for a difference in the order of occurrence for TBI etiologies. Motor vehicle accidents accounted for a higher percentage of TBI cases in the present study (67.5% compared with 49% previously). Falls were the second most common accident, followed by assaults, work (excluding falls) and sporting accidents. All cases involved blunt and closed head injury with deceleration forces predominating (86.4%), followed by acceleration forces (12.9%) and just one case of compressive head injury.

The severity of TBI was assessed by determining each patient's period of PTA, as is the convention where few Glasgow Coma Scales have been recorded. Two areas of concern throughout the study were inter-examiner reliability, where numerous clinicians and practitioners were assessing severity, and the reliability with which patients recalled their TBI event. The majority of patients (53.6%) had suffered severe TBI, however it was noticeable that some people with mild and moderate insult also suffered quite severe outcomes, possibly due to secondary injuries. This was generally reflected in their test performances and may explain some contradictory patterns in the TBI group. For example, whereas more mild than moderate or severe TBI subjects might have been anticipated in the active strategy group, such a ranking by degree of severity was not evident.

Overall, the TBI sample obtained in the present study was a good representation of the moderate to severely injured TBI population at large, but possibly under-representative of those with mild head injuries, many of whom choose not to seek medical care. The advantage of such a sample was a more precise evaluation of cognitive functioning amongst subjects at the severe end of the TBI scale.

Whereas a number of subject characteristics were considered, the three subject variables of age, education and occupation were all potential confounds to be considered in determining what subjects to include. It seemed important to match both TBI and control groups for these characteristics and suggested a need to expand the control group beyond just a volunteer student sample. It was anticipated that such a match might be achieved by including volunteers from the ranks of the unemployed and/or a prison population where such persons could be expected to display similar demographic characteristics. The choice of control subjects was also dependent upon availability and access to suitable persons and in sufficient numbers. Subjects in the experimental and control groups were not as easy to delineate as initially expected, since an unexpected finding of the present study was a disproportionately high number of individuals in the control groups who reported previous concussive episodes. Forty percent of controls tested had to be eliminated from the analysis for this reason, although such a number provide further supporting evidence for the appropriateness of the sample match. Further research is warranted to investigate the incidence and consequences of acquired brain impairment amongst unemployed and prison populations in New Zealand.

Overall, the demographic characteristics of TBI subjects included in the present study are similar to those of other TBI research. In terms of gender differences, earlier studies (Gronwall et al., 1990, Morse & Montgomery, 1992) have indicated that males are more prone to head injury than females, accounting for two-thirds or more of all TBI cases. This finding is supported in the present study where 72% of TBI subjects were male and 28% female. In contrast, the control group eventually contained a more even ratio of males (54.2%) to females (45.8%) and this difference may have confounded present results. Earlier studies (Bolla-Wilson & Bleecker, 1986; Bleecker et al., 1988) reported significant sex differences on the AVLT whereby women performed consistently better than men. This is meaningful in the present study because a greater proportion of controls were female and may, therefore, have elevated control performances. This situation arose because so many male controls had to be eliminated from the analysis due to their history of head injuries. Further, whereas the majority of the male controls were prison inmates, many of the female controls were extra-mural university students - a situation which suggests the potential for a difference in intelligence quotients.

Some tests for memory disabilities are sensitive to age effects in that it must be determined whether performance is affected by developmental influences in youngsters, cerebral deterioration through aging or tissue damage due to TBI. The AVLT has established norms for various age groups, but in the present study it was important to match TBI and control groups by age, especially given the high incidence of head injuries occurring in the fifteen to fifty age range. The mean and median age similarities between groups suggests this was largely achieved, although the control group is older by 3 to 5 years. The mean of around 31-32 is higher overall than anticipated and slightly deceptive since this reflects subjects' ages at time of testing rather than at time of their accident. The average interval between TBI event and subsequent neuropsychological assessment was 4.2 years (median 2.45 years), thus TBI subjects were that much younger when they sustained TBI. Another explanation for older controls stems from the inclusion of some subjects aged in their sixties who lifted the mean. Further, the inclusion of prison inmates - most of whom were 30 years of age or over may have lifted the mean age amongst controls.

Education is significantly related to neuropsychological test performance. Whereas with normal subjects there are often significant correlations between years of education and test scores, this is not so common with impaired subjects. The mean years of post-primary education amongst TBI patients was 3.7 years compared to 4.76 in the control groups, a significant difference which is consistent with the literature. However, this result may be confounded for two reasons. Firstly, a greater number of tertiary students were included as controls, which may have slightly elevated the levels of education recorded amongst controls, thus not providing a good match. Against this, it could be argued that those students were predominantly mature extra-murals, who, for the purposes of the present study, were recorded as students, but who in reality, may have been away from formal education for many years. No record was taken in the present study of their original levels of education but the distinction is likely to be blurred in any case, since extra-mural students have often been engaged in part-time study for a number of years. A further reason why the years of education amongst controls might be artificially high lies in the fact that a number of less-well-educated controls were excluded from the analysis because of their history of TBI.

The 3.7 years reported for TBI cases may also be higher than the actual, since it was not uncommon to find a certain vagueness amongst TBI subjects about their years at school. For example, some claimed to have three years of secondary education, when closer questioning revealed that they dropped out after only a few weeks or months of their third year, so that their effective secondary education was more like two years. This point was not always recorded accurately in collecting data and represents a design weakness in the methodology of the present study which should be corrected in future efforts.

Intelligence is also a potentially confounding influence in many neuro-psychological tests, but was not specifically included in the present study. A low score may be attributable to low intellectual abilities in an unimpaired person, brain impairment in a normal person, or poor performance caused by current emotional difficulties (Filskov & Locklear, 1981). This can be determined separately from the AVLT when an intelligence test is administered concurrently. A project to compare IQ scores and the use of learning strategies would be a fruitful area for future research, although some work has been done in this area (Bolla-Wilson & Bleecker, 1986).

Traumatic brain injury is more common in certain occupational groupings. The majority of TBI subjects (68.6%) were either tradespersons or labourers at the time of their injury and this factor, in combination with relatively low years of post-primary education and high risk taking behaviour are common precursors to TBI. The second largest group of TBI subjects were either students or beneficiaries (22%) with professionals represented by 9.3 percent. Amongst control subjects the ratios were quite similar for the first two categories (59.3% and 22% respectively) but included a higher number of professionals. Overall, the evidence suggests that TBI most commonly occurs amongst young males in low-skilled or trade occupations who are inclined to engage in risk-taking activities, possibly to impress peers and onlookers, but also because they lack insight and the ability to make an accurate judgement as to the hazard so are more prone to having an accident. Often the cognitive deficits associated with initial head injuries compound to further limit the individual's sense of judgement, such that subsequent TBI episodes are increasingly likely.

Whereas occupational skills can be useful indicators of pre-morbid levels of functioning, some test scores may be affected by occupations where specific overlearned work skills bear some resemblance to test items. Heuristically, skilled labourers tend to score higher on performance rather than verbal scales. It could be argued that TBI subjects in the present study, who derived largely from trades or labouring occupations, scored poorly because they were unpractised in those verbal learning tasks required for the AVLT. This problem was addressed by matching TBI and control subjects from a random range of occupations where a heterogeneous subject population was less likely to share the same skills.

It was considered important to determine the handedness of subjects, since this relates to such factors as hemispheric lateralisation for speech and language functions (Satz, 1977). The results indicate a preponderance of left-handed subjects in the TBI group, a finding which is interesting but difficult to explain. In the general population, approximately two thirds of left-handers show the normal pattern of lateral symmetry characteristic of right-handers where language is represented in the left hemisphere, however, smaller proportions show either right hemisphere or bilateral speech representation (Lezak, 1983). Are left-handed TBI victims more vulnerable to verbal memory difficulties? No tests for aphasia were included in the present study, neither were all lesion sites able to be determined in the TBI group. The issue of handedness is an area which should be explored in future research.

Test results from subjects suspected of psychiatric disturbance were omitted from the overall analysis since it remained beyond the scope of the present study to attempt any differentiation between brain-impaired and psychiatric patients. That is not to deny the possibility of such associations, for, as Boll (1978, cited in Filskov &

Locklear, 1981, p. 659) states, "we cannot assume that psychiatric disturbances are not neurological disorders, that psychiatric patients will not acquire brain damage, and that brain-damaged subjects do not develop psychiatric problems". These issues are more properly the subject matter for future research.

8.1. Hypothesis 1

> *That control subjects will score significantly higher than TBI subjects on the AVLT.*

This hypothesis provided the first indication of a demonstrable difference between TBI and control subjects' memory performance as tested in the present study. TBI subjects consistently performed below controls, demonstrating a slower learning curve and a more disorganised approach to learning. This is consistent with earlier studies (Waters, 1982; O'Donnell et al., 1988) who report that normal young adults apply increasing organisation strategies across learning trials, and the extent of this organisation is related to their subsequent recall performance.

Of interest was the finding of a disparate decline in group scores on post-interference trials 6 and 7, which are indicators of long term memory performance. With TBI subjects this was especially marked on trial 7 (recall following a 30 minute delay), where the mean number of words recalled was half that of trial 5. In contrast, control group mean scores showed no decline. Such a difference supports earlier findings (Levin et al., 1979) that patients with TBI rely excessively on STM and experience most difficulty with tasks involving LTM.

A further unexpected observation was the difference in performance of the two groups at trial 1. Since short term memory usually restores following TBI, it was surprising that TBI subjects performed poorer than controls right from the outset and seems to contradict earlier studies (Lezak, 1979) which report that deficits in learning ability are not always apparent on the first trial of the AVLT, but may show up on later trials. This suggests that TBI subjects were suffering from some other cognitive deficit, presumably connected to their brain injury, which resulted in a slower time to establish a response set and reduced ability to lift their performance to control levels over successive trials. It further lends support to a contention presented throughout the present study that memory difficulties often occur concomitantly with impairment of executive functioning. Figure 7:1 illustrates the progressive divergence in recall performance between TBI and control subjects where the former group demonstrate their impaired ability to organise the word lists for effective retrieval.

8.2. Hypothesis 2

> *That TBI subjects will adopt fewer active strategies than controls.*

Two kinds of self awareness are critical for learning: knowledge of facts and knowledge about process. The latter includes being able to predict one's own capabilities, being able to choose the best strategy in various situations and knowing how to allocate resources for the greatest efficiency (Cavanaugh & Perlmutter, 1982). That just 10% of TBI subjects used active strategies supports the notion that metamemory is impaired in many TBI patients, particularly in relation to their knowledge about the efficacy of various encoding strategies and their ability to establish the context in which new information should be remembered. Thus, their performance may not depend so much on adopting an appropriate strategy, as on first appreciating the need for a strategy (Cavanaugh & Perlmutter, 1982).

The fact that more controls (39%) used active strategies and fewer (6.8%) used no strategies at all, suggests that metamemory is operative in non-impaired populations but largely absent in cases of TBI. These findings are consistent with those of Lawson & Rice (1989) and Morse & Montgomery (1992) who earlier reported the absence of spontaneous strategy use in TBI patients. An important distinction should be drawn between "spontaneous" and "instructed" strategy use at this point. Whereas patients with TBI do not spontaneously adopt memory enhancing strategies they can sometimes be taught strategy techniques in an external training context. This suggests that the problem is not due to deficits in the memory process, but rather to impairment of the executive system (metamemory), and that the effect of instruction is to provide a substitute or compensatory external executive system. Such a supposition helps to explain why instructed patients show poor ability in the transfer of strategy techniques to novel situations and poor maintenance of performance once external prompts are withdrawn (Lawson & Rice, 1989).

Thus, in normal populations, the majority of people spontaneously adopt learning strategy techniques and the success, or otherwise, of their performance depends only upon the type of strategy employed. In contrast, success or otherwise in the performance of most TBI subjects is unlikely to depend upon any strategy use, because the higher cognitive processes such as metamemory and executive functioning which initiate strategy adoption are compromised or eliminated at time of injury. Whereas strategies are important, so are those higher cognitive processes which precede them. Both in combination are essential to normal learning and difficulties result where one or each are absent.

8.3. Hypothesis 3

> *That for both TBI and control groups, subjects using active strategies for learning will perform significantly better on the AVLT than those using passive strategies who, in turn, will perform significantly better than those using no strategies at all.*

The AVLT is considered a useful measure for revealing learning strategies or their absence (Lezak, 1983). A feature of the present study was the creation of <u>three strategy groups</u> into which subjects were classified according to the type of spontaneous strategies evidenced during administration of the AVLT. The most effective group adopted <u>active</u> strategies and scored better than other groups. More controls (39%) used active strategies than TBI subjects (10.6%) and there was a significant difference in their performance. The greatest majority of all subjects were included in a second group which employed <u>passive</u> strategies. Again, TBI subjects scored significantly below controls in the passive strategy group although both scored better across all trials than the no strategy group, but still less than the active group. The least effective group included those who used <u>no strategies</u> at all. These subjects scored lowest on all AVLT trials (see Figure 7.2.), and more TBI subjects (25.5%) were represented in this category than controls (6.8%). Thus, it is apparent that some strategies were more effective than others and that whilst TBI subjects were capable of adopting learning strategies at one of the three levels, their performance matched that respective level.

8.4. Hypotheses 4 & 5

> *4. That control subjects adopting active strategies will perform significantly better than TBI subjects using active strategies on the AVLT.*
>
> *5. That the smallest difference in performance between TBI and control groups will be found between those using active strategies.*

What are the characteristics of those TBI subjects employing optimal strategies? Are they the less severely head injured, or were their injuries confined to less critical areas of the brain? Why do some TBI subjects have a residual learning ability whilst others do not? Closer examination of the groups using active strategies is included here to highlight performance under optimal strategy regimes. The sub-group of TBI subjects who employed active strategies demonstrated a learning curve which ran closely parallel to their active control counterparts across trials 1-6, albeit at a level slightly below. Thereafter, on trial 7 each group diverged sharply (see Figure 7.3.) with active controls maintaining their best pre-interference scores, whilst TBI actives slipped back almost to their trial 1 level. One explanation for this may arise from the substitute external executive system proposition of Lawson & Rice (1989) whereby the examiner's repeated presentation of words on each early trial provided a sufficient prompt to aid retention in STM for TBI subjects. When this prompt was withdrawn in the post-interference trials, recall for individual TBI patients declined to levels commensurate with their LTM deficits.

There does not appear to be an interference effect, for as can be seen in Figure 7.6, TBI subjects showed only a negligible response to retroactive interference, and in any case, their scores on trial 6 were not affected. Rather, their decline in performance seems to have come after the 30 minute delay, thereby suggesting that transfer to LTM had not occurred, but also implying that sufficient time had elapsed for TBI subjects to forget their strategy technique as well. At this point, three conclusions can be drawn about verbal memory performance generally. Firstly, TBI subjects have to rely on STM because they typically suffer LTM deficits which may occur within a time span of less than 30 minutes. Secondly, where TBI subjects successfully combine STM and optimal strategy techniques, their short-term learning curve improves to closely parallel that of normal controls. Thirdly, with delay, TBI subjects not only lose the advantage gained by using strategies, but are also at risk of forgetting their strategy technique, so that subsequent learning attempts will require them to start from scratch in developing a new strategy. That they appear unable to activate the cognitive processes necessary to retrieve their initial strategy provides further evidence of impaired metamemory contributing to their lower performance.

8.5. Hypothesis 6

> *That TBI subjects will be more susceptible to interference effects than controls.*

Proactive was more apparent than retroactive interference, indicating that words from the first list interfered with learning of those on the second list more than the second interfering with the first. One explanation for this hypothesis not being supported may be that controls endeavoured to concentrate hard on actively learning each word list and so became more susceptible to interference effects. In contrast, TBI subjects lacking the same powers of concentration devoted less attention to the distracter trial, focusing instead on either rote learning (a primacy effect) or short term memory (a recency effect). Alternatively, some patients with TBI may have exhibited perseveration, and thus never shifted their attention from the first word list. Although controls were more susceptible to interference effects, they consistently scored better than TBI subjects.

8.6. Hypothesis 7

That there is no difference between TBI and control subjects in the number of intruding words.

In addition to immediate memory span, the AVLT reveals errors of commission which provides useful information about subjects' attentional abilities, self-monitoring and tracking (Lezak, 1983). Such errors may indicate difficulties in distinguishing between list words and outside words (intrusions) or between items presented at different times, as when words from two presented lists are confused (contamination). Brooks (1975) suggested that a significant rate of intrusion errors occurring amongst TBI subjects would indicate that the deficit was not one of retrieval, but rather retention in LTM. Items were retrieved incorrectly because they had not been retained in storage appropriately.

In the present study, the majority of subjects in both groups introduced between one and three outside words. Whereas more controls (41.5%) recorded one outside word than TBI subjects (29.3%), the group differences overall were not significant for subsequent intrusions. The same can be said for contamination errors as set out in Table 7.7a, where the percentage of inter-list confusion was very similar for both TBI and control groups. Thus, neither difficulties in discerning intruding words nor contamination of inter-list words appear to be factors contributing to the poorer memory performance of TBI subjects.

8.7. Hypothesis 8

That there is no difference between TBI and control subjects in the number of words repeated.

Recording the number of words repeated also provides useful qualitative information about subjects' performance and levels of confidence. Subjects may correct themselves several times, or question whether they have already repeated a word but still remain unsure. Some may continue to repeat individual words or small groupings of words long after they have clearly exhausted their recall for that particular trial. In the present study, the majority of subjects in both groups repeated between 1-5 words. In the first instance, 33.8% of controls repeated one word compared to 17.6% of TBI subjects. Thereafter, the respective percentages were quite similar, even as far as the repeating of eight words. The performance of TBI subjects was no worse than controls in this respect and therefore did not contribute to the poorer memory performance of TBI subjects.

8.8. Hypothesis 9

That the order of words recalled across all Trials will reflect the difference in learning technique between TBI and Control groups, i.e. subjects with lower AVLT scores will demonstrate rote learning which is associated with primacy effects, which is a passive strategy and a LTM phenomenon commonly compromised following TBI.

A final analysis of the present study examined the overall order in which words were recalled, both within and between trials. Were certain words recalled more often and in a certain order to others? As a rule of thumb, the 15 word list of AVLT might be ordered three ways: words 1-5, primacy effect, words 6-10 middle and words 11-15 recency effect. Results as shown in Table 7.9. reveal a similar rank order effect for both TBI and control groups. Trials 1-5 were characterised by primacy (first words) first, recency (last words) second and middle words last. This is consistent with earlier studies by Rundus (1971) and Brooks (1975) who reported similar serial position effects.

Passive strategies were used most of all by both groups and primacy effects are linked to rote learning which is identified as a passive strategy and which reflects the absence of any planning or organised approach to learning. Rote learning relies on continuous attention and rehearsal to hold items in STM, a technique which fails when subjects presented with 15 words hit overload at 7 plus or minus 2, since they have not anticipated such overload nor organised to overcome it. Thus, when word recall in the primacy range is exhausted, subjects resort to recency recall - the only items still vaguely in STM. Finally, subjects may draw on any residual memory capacity to recall words from the middle of the list - a typical verbal memory pattern. In such circumstances, TBI subjects would be expected to score lower than controls overall, because of their impaired LTM ability.

However, in post-interference trials 6-7, the order effect changed to recency, middle then to primacy. Subjects resorted to recency items presumably as these were still in STM. Middle and primacy items came afterwards but only if transfer to LTM occurred successfully. Consequently, scores on post-interference trials 6-7 are often less than earlier trials, with TBI performance poorer than controls.

CONCLUSIONS

Long term memory is a critical deficit in patients with TBI. Long term memory occurs when information is transferred from STM, and memory problems may be attributed to a failure in this transfer process. In order to learn new information, it is generally necessary to apply some form of learning strategy. In cases of neurological impairment, the ability to employ spontaneous learning strategies is often absent due to compromised cognitive processes such as slowed mentation, decreased initiation, or higher level attentional deficits, especially in moderate to severe cases of TBI. The present study examined the spontaneous use of learning strategies amongst TBI patients and a control sample. On the AVLT, TBI subjects exhibited a range of performance deficits which included a disorganised approach to learning, a slower learning curve, erratic performance across trials, and perseveration with certain words. Particularly noticeable in the TBI group was a significant decline in performance for trials 6 and 7 which are indicators of LTM. Scores for these recent and delayed recall trials showed no advance on those for trials 1 and 2, which represent STM. In contrast, control subjects progressively increased their scores across trials 1 to 5 and maintained their performance through trials 6 and 7.

The present study examined the **spontaneous** application of learning strategies amongst patients with TBI. It did not test memory performance under conditions involving strategy instruction. A follow-up study which compared spontaneous and instructed strategy use would provide further insight into metamemory functioning by assessing whether those TBI patients not spontaneously adopting learning strategies would be able to do so with instruction, and whether such would then generalise to other novel situations? Where instruction is given, the aim should be to teach "active" strategies, which, as the present study has discussed, do involve effortful and elaborative processing but which ultimately yield the best results. Another area for future study would involve greater "testing of the limits" in administering the AVLT to TBI patients. Would more instruction before testing, or slower administration of the AVLT produce better scores? How much of the difference in performance is due to TBI subjects not understanding the instructions in the first place? What is the effect of starting both groups on a similar trial score? Does memory actually decline or is it more the nature of the AVLT task?

The present study does not advocate teaching TBI patients particular mnemonic techniques in rehabilitation. Under spontaneous learning conditions, these subjects showed they could use various strategies as a STM aid, but consistently failed to carry those strategies over to LTM. It seemed that after a delay of no more than 30 minutes they forgot what strategy they had been using and even lost awareness that a strategy was necessary. It is not yet clear whether patients with TBI can be taught metamemory processes which will enable them to perform more quickly, smoothly, efficiently and to process less information, nor whether their performance can become automatic with the development of skill. Where memory is impaired, an alternative cognitive re-training approach might be to encourage the development of such self-monitoring and other metacognitive skills. The question then is whether performance will improve if metamemory deficits are restored through retraining? Will patients with TBI be able to distinguish between relevant and irrelevant situation cues in order to reduce STM overload and thus to ease their processing capacity? Will they adopt appropriate control and self-monitoring processes to avoid erratic recall of items? These questions remain the subject of future studies. What is now clear from the present study is that strategy use alone does not improve LTM, but is a STM palliative only.

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APPENDIX A

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FACULTY OF
SOCIAL SCIENCES

DEPARTMENT OF
PSYCHOLOGY

REY AUDITORY-VERBAL LEARNING TEST

	List A	List B	List C
1	Drum	Desk	Book
2	Curtain	Ranger	Flower
3	Bell	Bird	Train
4	Coffee	Shoe	Rug
5	School	Stove	Meadow
6	Parent	Mountain	Harp
7	Moon	Glasses	Salt
8	Garden	Towel	Finger
9	Hat	Cloud	Apple
10	Farmer	Boat	Chimney
11	Nose	Lamb	Button
12	Turkey	Gun	Key
13	Colour	Pencil	Dog
14	House	Church	Glass
15	River	Fish	Rattle

(Lezak, 1983, p. 423).

APPENDIX B

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FACULTY OF
SOCIAL SCIENCES

DEPARTMENT OF
PSYCHOLOGY

PARTICIPANT INFORMATION SHEET

REY AUDITORY-VERBAL LEARNING TEST

What is this study about?

This study is a simple and straightforward technique for testing memory. It evaluates the ability of individuals from different life circumstances to remember spoken lists of words. The project is being conducted by Mr. Brad Grimmer, a researcher in Neuropsychology and Dr. Janet Leathem, Senior Lecturer and Director of the Psychology Clinic at Massey University.

What Would I have to do?

If you agree to take part, the researcher will arrange an appointment, at a suitable time and place that will take about 30 to 45 minutes of your time. You will not be required to write anything down.

What can I expect from the Researchers?

If you take part in the study, you have the right to:

* a full explanation of the nature of the study being undertaken, prior to your inclusion.
* ask any further questions about the study that occur during participation
* refuse to answer any particular question or to withdraw from the study at any time.
* provide information on the understanding that it remain completely confidential to the researchers. All records will be identified only by code number, and will be seen only by the researchers. It will not be possible to identify any individual in any reports that are prepared from the study.
* be offered a summary of the findings from the study upon its completion.

Should you wish to clarify any further points, you are welcome to contact Brad Grimmer at (06) 356 4455.

APPENDIX C

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FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF PSYCHOLOGY

REY AUDITORY-VERBAL LEARNING TEST

PARTICIPANT CONSENT FORM

I have read the Information Sheet for this study and have had the details of the research explained to me. My questions about the study have been answered to my satisfaction and I understand that I may ask further questions at any time.

I also understand that I am free to withdraw from the study at any time, or to decline to answer any particular questions in the study. I agree to provide information to the researchers on the understanding that it is completely confidential.

I agree to participate in this study under the conditions set out on the Information Sheet.

Name:________________________

Signed:_______________________ Date:_________

Statement by researcher:

I have discussed with ________________________ (participant's name) the aims of and procedures involved with this study.

Signed: ________________ (researcher) ________________ (Print Name)

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APPENDIX D

NEUROPSYCHOLOGICAL ASSESSMENT

CLIENT DEMOGRAPHIC SHEET

ID #:

NAME________________________________

DATE OF BIRTH________________________

OCCUPATION__________________________

SEX	Male Female
RACE	European Maori Pacific Islander Asian Other
EDUCATION	High School 1 yr 2 yrs 3 yrs 4 yrs 5 yrs
Tertiary	1-2 yrs 3-4 yrs 5 yrs +
HANDEDNESS	Dominant Right Dominant Left Ambidextrous

DATE SEEN AT CLINIC (SAC)

DATE OF ACCIDENT (DOA)

PERIOD OF ANTEROGRADE AMNESIA (AA)

PERIOD OF RETROGRADE AMNESIA (RA)

DESCRIPTION OF ACCIDENT

* Cause of Injury	Motor Vehicle	Industrial	Fall
	Assault	Recreation	Sports
* Place of Injury	Highway Home	School	Work Sports

* RELEVANT MEDICAL HISTORY (any previous head injury?)