The effects of Traumatic Brain Injury on Complex Figure Test performance.

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ABSTRACT

Patients with Traumatic Brain Injury (TBI) have performed below norms on the Complex Figure Test (CFT) and this has been attributed to lack of organization (Binder, 1982). The present study compared 105 TBI subjects with 59 Controls in terms of accuracy and organization to examine whether lower TBI subject organization was associated with subsequent lower accuracy. Results showed that TBI subjects scored lower accuracy than controls on copy, recall and delay trials but did not score lower for organization (as measured by Hamby, Wilkins & Barry, 1993). Both groups were consistent in organizational approach across the three CFT trials, and copy organization scores of both groups were positively correlated with accuracy scores on recall and delay trials. This suggests that TBI subjects do have a problem with the CFT, but it cannot be linked to copy organization on the basis of evidence from the present study. The unexpected results were attributed to methodological problems involving the population samples and the organization measure.

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CHAPTER 1: INTRODUCTION

Traumatic Brain Injury (TBI) is the most common cause of brain damage (Kurtzke, cited in Lezak, 1995), and has become "a major health problem in westernized nations" (Jennett & Macmillan, 1981). The economic and social costs associated are high.

Those who are most at risk from TBI are males aged between 15 and 24 years, who typically sustain their injuries in motor vehicle accidents (MVA) (Bond, 1986). These typically result in closed-head injuries (open-head injuries account for only 2-6% of all cases). Damage is caused by the initial blow, shearing strain (which damages major neural pathways), and secondary injuries such as haemorrhage and hematoma. Neuropsychological consequences generally consist of impairment in attention, memory, behaviour and personality, and language and communication. Of these, memory impairment is the most common problem reported after TBI by patients and their families (Bond, 1986). The basis for the memory difficulty appears to be at the encoding stage, where material is organized for storage (Craik & Lockhart, 1972).

Assessment after TBI is essential as it outlines the nature and extent of difficulties. Many deficits detected in this way may be linked to injuries which are not immediately obvious, and those that are obvious may be confused with other disturbances. Neuropsychological assessment focuses on such faculties as general intelligence, attention, memory, and personality factors. One of the most commonly used tests of memory is the Rey Complex Figure Test (CFT), developed in 1941 by Andre Rey. The task requires a subject to copy a complex geometric figure, then redraw it from memory, first after a brief period, then after approximately 30 minutes.

An organized approach to the CFT involves drawing elements of the base rectangle first, then methodically filling in the various details. Previous research has shown that a disorganized copy of the CFT results in a lower score than an organized approach (Binder, 1982; Klicpera, 1983; Bennett-Levy, 1984; Heinrichs & Bury, 1991; Hamby, Wilkins & Barry, 1993). Those with TBI tend to make disorganized copies, and consequently obtain lower accuracy scores than non-brain injured subjects (Binder, 1982). One of the drawbacks of Binder's (1982) study is that the method of evaluating organization was extemely basic. For example, elements in each CFT drawing were rated only as either correct, missing or fragmented, further only 14 subjects were included in each group. More recently, Giarratano and Tate (1993) modified the test providing 12 TBI patients with an organized approach (by systematically presenting broken-down segments), and brain injured subjects' recall was equivalent to non-brain damaged controls.

The present study represents an attempt to re-examine the relationship between TBI and organization on the Rey CFT using a larger sample of TBI subjects. The accuracy of TBI subjects was investigated, in order to confirm that this group scored lower than controls. These subjects were also expected to use a more fragmented approach to the task. The consistency of TBI and control group use of strategy was compared, and finally the relationship between copy organization and recall and delay accuracy was examined.

The following chapters provide background information and theory relevant to the study. Chapter 2 includes an overview of important theoretical advances relating to memory. Chapter 3 looks at TBI: its incidence and classification, and the consequences of the condition. Chapter 4 examines the Rey CFT, its application to TBI patients and the various methods of scoring the test. Chapters 5 to 7 describe the objectives and hypotheses of the present study, the methodology used in their examination, and the results. The discussion in chapter 8 interprets the results, compares them to previous research, and finally, makes suggestions for future research.

CHAPTER 2: TRAUMATIC BRAIN INJURY (TBI)

INCIDENCE

Traumatic brain injury (TBI) is one of the most common disorders leading to hospital admission (Miller, 1993). It is difficult to reliably estimate the frequency of TBI within a given population due to disagreement as to what level of injury actually damages the brain (Kolb & Whishaw, 1990). Reported incidence in the United States varies from 500,000 to 1.9 million per year (Lezak, 1995), or alternatively, approximately 180 hospitalizations per 100,000 population (Kraus & Nourjah, 1989). In the United Kingdom, between 200 and 300 hospitalizations per 100,000 occur (Miller, 1993).

An indication of TBI incidence in New Zealand can be derived from Accident Compensation Corporation (ACC) statistical data. In 1994, 5284 new claims were lodged with the ACC for compensation after head injury, with actual claims paid out totalling $1,209,000. For 1995, 5152 claims were made, and $1,373,000 was paid (ACC injury statistics, 1994-1995).

The most important factors in the incidence of head injury are age and gender. Most victims are those aged between 15 and 24 years (Lezak, 1995). Males outnumber females by at least two to one (Levin, 1989a; Lezak, 1995). Motor vehicle accidents account for half of TBI followed by falls, where children and the elderly are disproportionately represented (Spivack & Balicki; cited in Lezak, 1995).

CLASSIFICATION

The two main methods used to assess severity of TBI in the immediate post-injury period are the Glasgow Coma Scale and length of post-traumatic amnesia. More recently scanning methods have shown some potential.

Glasgow Coma Scale (GCS)

Coma can be defined as "a state of unarousable neurobehavioral unresponsiveness (Giacino & Zasler, 1995, pp 42)", and it has been identified as significantly related to outcome (Dikmen, Machamer, Winn & Temkin, 1995). The Glasgow Coma Scale (GCS) (Teasdale & Jennett, 1974) measures the presence, degree and duration of coma, giving an objective indication of conciousness. Three indices are used: eye opening, motor response and verbal response. A score below 8 on the GCS indicates severe injury, while scores of between 9 and 12 suggest moderate injury, scores of 13 to 15 indicate no coma, and therefore light injury. One problem with the GCS is that approximately 50% of TBI hospital admissions score 13 to 15, and while this indicates no coma, serious injuries may have been sustained nonetheless (Kolb & Whishaw, 1990). Further, the GCS looses its predictive utility after the acute period has passed, and is insensitive to subtle changes in responsiveness (Giacino & Zasler, 1995).

Post-Traumatic Amnesia

An alternative measure of TBI severity is length of post-traumatic amnesia (PTA). The definition of PTA can vary, as it may include the period of coma or be limited to the period of anterograde amnesia (Kolb & Whishaw, 1990). Generally PTA is the period preceding restoration of memory for ongoing events including the duration of coma (Levin, 1989a). PTA of 5-60 minutes indicates mild injury, 1-24 hours moderate injury, 1-7 days severe injury, 1-4 weeks very severe injury and more than 4 weeks, extremely severe. Accurately assessing the length of PTA can be difficult (Dikmen et al., 1995), since it is usually based on a patient's often disoriented self-report or retrospective account. Nevertheless, PTA has been found to predict long-term cognitive status after TBI more accurately than coma duration (Brooks et al.; cited in Lezak, 1995).

Scanning Methods

Once the immediate danger is over and the patient is hospitalized, more sophisticated neurological assessments can be performed. A computerized axial tomography (CT scan) uses xrays to construct images of the brain, and can identify lesions, hemotoma and other abnormalities (Miller, 1993). It is fairly insensitive, however, to the subtle effects of closed head injury (Long & Schmitter, 1992).

Another test is magnetic resonance imaging (MRI). This method measures the electromagnetic energy of cerebral nuclei and forms an image of the brain, revealing structural abnormalities (Kalat, 1992). The MRI is more sensitive than the CT scan and can reveal defects in those who had been thought to have only minor injuries (Miller, 1993).

PATHOPHYSIOLOGICAL CONSEQUENCES OF TBI

A head injury can damage the brain in a number of ways. Direct damage can be caused by an impacting object such as a bullet or skull fragment, or may disrupt the blood flow to many brain areas. Internal bleeding or tissue swelling increases pressure on the brain leading to additional damage. Infections and scarring often lead to complications after the initial danger has passed.

As well as classification into severity levels, TBI can be classified as penetrating or non-penetrating (open and closed head injuries). Although the categories may overlap in some cases, they generally involve very different consequences for the survivor.

Closed-Head Injuries (CHI)

Injuries where the skull is not penetrated are by far the most common (Lezak, 1995). The pathophysiology of closed-head injury is traditionally divided into primary and secondary injury. Primary injuries are largely complete at the time of impact and are regarded as irreversible (Miller. 1993). Secondary injuries are additional complications causally related to primary injuries (Pang, 1989).

Primary Injuries

When the head is struck, it rapidly accelerates forward, and, because the brain is less dense than the skull, it will "lag behind" before being dragged forward with the skull. This causes the "rubbing" of the cortex against the skull's rough inner surface. If the accelerating head then meets a solid object (the ground), it decelerates to an instant stop, leaving the brain to continue forward before being forced against the inside of the skull, repeating the "rubbing" in reverse.

The twisting and rotation of the head during impact causes what Pang (1989) calls "shearing strain." This occurs when parts of the brain (which is lagging behind the accelerating skull) are dragged forward by protruding pieces of skull, becoming damaged. Different structures within the brain are connected by neurons, axons and capillaries whichare vulnerable to the distortions caused by shearing strain. A severe case of shearing strain can effectively disconnect the cortex from subcortical structures, leading to a largely vegetative state.

Secondary Injuries

Secondary injuries are extremely common (Miller, 1993), and can cause as much, if not more damage than the primary injury (Lezak, 1995; Pang, 1989). One of the main causes of secondary injury is haemorrhage (bleeding) and various associated sequelae. Growing masses of blood (hematoma) exert pressure on the brain, and additional pressure is caused by increasing amounts of water in the brain (edema). Increasing intracranial pressure generally leads to loss of conciousness (Kolb & Whishaw, 1990) and can transform an apparently mild CHI into a life-threatening condition in a few hours (Jennett & Teasdale, 1981).

Open-Head Injuries

Open-head injuries account for only 2-6% of TBI cases brought to medical attention, and they result from military combat, suicide attempts, crime (bullet wounds) and miscellaneous accidents such as hunting and work-related accidents (Kampen & Grafman, 1989). The level of damage caused by brain injuries varies according to the type of penetrating object, the location of entry and the object's velocity (Kampen & Grafman, 1989). Tissue damage tends to be concentrated along the path of the foreign object. Consequently, symptoms are distinctive and focal, and can rapidly subside (Kolb & Whishaw, 1990). Although survivors of bullet wounds to the head, for example, have more seizures than closed-head injury survivors, they may not lose conciousness (Kampen & Grafman, 1989), and may regain adequate functioning almost immediately (Kolb & Whishaw, 1990).

NEUROPSYCHOLOGICAL CONSEQUENCES OF TBI

The diffuse nature of most TBI and the high likelihood of secondary complications create a wide variety symptoms, and they are cumulative in nature (Parker, 1990). Often these symptoms do not become apparent for days or weeks after the accident (Lezak, 1995). Only careful neuropsychological assessment will show the full extent of a patient's injuries. Although direct blows to the head will result in focal lesions and correspondingly focal behavioral effects, most TBI patients will display similar general impairments, caused by the widespread damage of shearing strain. These impairments usually involve the following areas: attention, memory, behaviour and personality, and language and communication.

Attention

Attentional deficits are common after TBI, particularly closed-head injury (Ponsford & Kinsella, 1992; Shum, McFarland & Bain, 1994). When severe these can be extremely disruptive, affecting all other areas of the patient's life (Lezak, 1995). Although patients appear to experience hyper-alertness, confusion, distractibility and reduced concentration (Parker, 1990), there is some disagreement as to the exact nature of the attentional deficits (Shum, et al., 1994). Slowed mental processing appears to be the fundamental attentional problem, with TBI patients apparently sacrificing speed to maintain accuracy (Ponsford & Kinsella, 1992).

Memory

Memory disturbance is the deficit that TBI patients and their relatives report most aften and most readily (Bond, 1986). These interfere with everyday functioning and limit dependency (Schmitter-Edgecombe, Fahy, Whelan & Long, 1995), and usually consist of acquisition and retrieval difficulties, with short-term memory being affected less (Lezak, 1995). Memory assessment should be thorough, because deficits in this area may only be representative of a more general cognitive deficit (Jennett & Teasdale, 1981). For example, a lowered speed of information and organization may lead to forgetting, and so may a lack of intention to learn (Brooks, 1989). In addition to impaired retention, TBI patients also show isolated problems related to specific lesions; left temporal lobe lesions lead to specific verbal learning difficulties (Levin, 1989b). Right hemisphere lesions tend to impair visual memory (Jennett & Teasdale, 1981). The most common TBI memory disorder involves impaired episodic memory (memory for specific events), while semantic memory (for general knowledge items) remains relatively intact (Sohlberg & Mateer, 1989). While routine activities (including work) are still possible, they have great difficulty performing new tasks and learning new skills (Bond, 1986; Jennett & Teasdale, 1981).

Behaviour/Personality

Levin and his colleagues (1987) found significant change in patients' social interaction and personality, and that often these losses were not recovered. Lezak (1978) described 5 categories of behavioural difficulties common to TBI people:

1) Emotional change (apathy, silliness, irritability)

2) Impaired social perceptiveness (lack of self-criticism)

3) Impaired self-control (impulsiveness, restlessness and impatience

4) Increased dependence (lack of initiative and planning)

5) Behavioural rigidity (inability to learn from experience)

These problems can result in a low morale and/or depression (Parker, 1990).

Language/Communication

Language skills have been thought to be relatively resilient to TBI, but recent evidence indicates long-term language and communication problems following Closed head injuries (Chapman, Levin & Culhane, 1995). Some of the most vulnerable skills appear to be reading (dyslexia) and writing (agraphia) (Parker, 1990). Dyslexia may involve nonsense syllables and word substitution. Agraphia can be due to problems of syntax, spelling or word choice. Aphasia (speech problems) with TBI people can involve difficulty moving from topic to topic, retrieving words, staying on the subject and reasoning abstractly (Groher, 1983).

It appears that these problems are linked to more general intellectual functioning deficits (Bond, 1986; Parker, 1990).

PROGNOSIS

The level of recovery achieved by a patient depends upon a number of factors, including various pre-injury characteristics, and the type and severity of the injury.

Pre-injury characteristics

Although pre-injury information is often difficult to attain, a patient's current status and probable outcome can be judged using this data. One of the most important predictors of outcome is age. Younger adults recover more rapidly than older adults (Goldstein & Levin, 1995; Long & Schmitter, 1992), both in terms of physical aptitude and resumption of independant functioning. Recovery tends to be greater among those with higher IQs, high socio-economic status and education (Rimel, Giordani, Barth, Boll & Jane, 1981, cited in Long & Schmitter, 1992). Those with lower education levels, unstable work histories and low earnings return to work at a slower rate (Dikmen & Machamer, 1995). Personality factors also appear important to outcome. Those who are described as less egocentric, responsible, "socially minded individuals" before injury recover (Kozol, 1946, cited in Long & Schmitter, 1992). Other important predictors include the availability of a social support system (Long & Schmitter, 1992), and, to some extent, alchohol abuse (Dikmen & Machamer, 1995).

Injury severity

Severity of damage influences neuropsychological outcome (Lezak, 1995). While those with mild injuries often return to normal functioning within several days, patients with severe trauma may remain in a vegetative state for an extended period (Giacino & Zasler, 1995), and often experience major changes in personality and functioning ability.

Most cases of TBI involve mild to moderate injury, and approximately half of these return to their pre-injury level of functioning, the remainder who, although independent in daily lifestyle, do not achieve their pre-injury status (Miller, 1993).

CHAPTER 3: MEMORY

As indicated in chapter 2, disorders of memory are commonly reported after TBI by victims and their relatives (Bond, 1986). These disturbances vary according to the severity and location of brain damage (Levin, 1989a), and in order to define and rehabilitate a memory disorder the accurate identification of a patient's particular problem is essential. For example, what is reported as an impairment of memory may in fact be an attention problem, or linked to more general intellectual deficits. (Jennett & Teasdale, 1981). Cognitive theory provides different models of memory that are invaluable in the identification of memory disturbances, and the following is an overview of these theories.

THEORIES OF MEMORY

The traditional model of memory proposed by Atkinson and Shiffrin (summarized in Solso, 1991) consists of three stages: sensory register, short-term store (STS) and long-term store (LTS). Incoming information is either discarded or passed on for further processing. The shortest stage, sensory register, retains information after the presentation of a stimulus. This information decays and disappears rapidly, being susceptible to interference. From the sensory register information is passed to the STS where *control processes* take place, the most important being *rehearsal.* Often there is a need to analyse or manipulate the material, and these processes are regarded as *working memory.* Long-term store is relatively permanent, not only storing information from the STS, but monitoring information within the sensory register.

Fundamental to the Atkinson-Shiffrin model is the control (concious or unconcious) that the individual has over the STS. Information can either be encoded and rehearsed in the STS to transfer it to the LTS; or it can be discarded to allow other stimuli to be analyzed. For example, TBI patients appear to have attentional deficits, and this may interfere with control processes taking place in the STS.

Information Processing Theory

Craik and Lockhart (1972) developed another model that described human memory as having different levels of processing rather than clearly separate "boxes in the head" such as STS and LTS. The levels through which information travels include attention, encoding, storage, consolidation and retrieval. These levels are not discrete; they are regarded as a single continuous process.

Whether stimuli are processed at an early level or at a deeper, more complex level depends upon the type of stimuli involved and the time available. The **attention** level involves sensory analysis, calling for the *preparedness* of perceptual systems and focused concentration *(vigilance)* to allow information to proceed to subsequent levels of processing. The **encoding** level determines how well an item will be recalled. If information is encoded *semantically* (in a way that is meaningful) it will be better recalled than if it were encoded in a non-semantic manner, such as *phonologically*, or according to the sound of words (Craik & Tulving, 1983). Encoding therefore aids **storage**, referring to the level where information is transferred to a structure or process of the brain for permanent availability. If memories are *consolidated*, or amalgamated into the existing cognitive foundation,

then the final level of processing, **retrieval,** will be easier. This level involves reactivation of memories and monitors which information is retrieved.
The Information-processing model provides a useful basis from which memory difficulties caused by TBI can be identified. Sohlberg and Mateer (1989) describe possible memory disruption during each stage of information processing. For example, difficulties in language, perceptual ability and integration of semantic information may lead to memory problems, and this is regarded as an *encoding* disruption. Alternatively, patients may encode information appropriately but be unable to maintain it in *storage*.

Declarative and Procedural Memory

A limitation of the above theories is that they deal only with memories that involve factual information. Cognitive Psychologists, however, describe at least two distinct memory systems (Eysenck & Keane, 1995). Cohen (1984) distinguished between *declarative* knowledge and *procedural* knowledge. *Declarative* knowledge ("knowing that") incorporates episodic memories (for specific information or events) and semantic memories (general knowledge items), while *procedural* knowledge ("knowing how") involves the ability to carry out skilled actions unconciously, such as riding a bicycle. The two types interact, as most human activities involve both declarative and procedural knowledge. Tulving (1985) further divided semantic memory into *procedural* and *propositional* memories. Procedural memories include riding a bicycle and tying shoelaces; they are mostly unconcious processes. Propositional memories involve knowledge that is common throughout society, such as the colour of the sky.

It was stated in chapter 2 that TBI patients have difficulty performing new tasks and learning new skills; it is also apparent that these patients experience impaired declarative memory, yet their procedural systems remain relatively intact (Cohen, 1984; Tulving, 1985). More specifically, it is common for TBI patients to have impaired episodic memory while their semantic memories remain. Tulving's case study of "K. C." is a good example: This individual understands the rules of chess well, but cannot recall ever actually playing the game. TBI patients also display this characteristic for information learned after their injuries (Sohlberg & Mateer, 1989.)

The above theories interact and are generally used in conjunction. For example, episodic and semantic memories can be viewed in information-processing terms, involving attention, encoding and retrieval. In fact, Tulving (1983; 1985) described quite specific encoding and retrieval processes for both types of memory.

VISUAL MEMORY

A large part of human memory involves remembering what things look like, and people are constantly adding to their stores of visual appearances, whether recognizing faces, buildings or other objects (Humphreys & Bruce, 1989).

Just as different levels of verbal memory are described in the relevant literature, visual memory can also be categorized into the traditional levels of sensory store, short-term visual memory and long-term visual memory.

Sensory visual memory, also known as *iconic memory,* is the momentary persistence of visual impressions and their brief availability for further processing (Neisser, 1967). It is regarded as an initial and essential information extraction stage of visual pattern perception (Schiffman, 1990), having a duration of less than one second and a relatively large capacity (Bourne, Dominowski, Loftus, & Healy, 1986). While there is some question as to whether a sensory phenomena such as this should be regarded as memory, iconic memory does involve storage (Solso, 1991). There is also argument as to the practical utility of iconic memory, and whether this store contains more information than we can remember.

The next level of visual memory is *short-term visual memory*. Here, recent events and/or objects are actually visualized, just as in the traditional short-term verbal memory model described earlier. Short-term visual memory has been termed a "visuo-spatial scratch-pad" by some researchers (Humphreys & Bruce, 1989), and is used when constructing, maintaining and manipulating present and remembered images.

The effectiveness of the next stage, *long-term visual memory* (LTVM), has been demonstrated by various researchers (reviewed in Humphreys & Bruce, 1989). Subjects presented with hundreds of pictures and later asked to identify whether pictures are "old" (originally shown) or "new", were able to correctly identify pictures 98% of the time. In fact, it appears that we remember pictorial information more easily. According to Paivio's "dual coding" theory (1971, cited in Bourne et al., 1986) both verbal and image codes are used to encode information for storage into long-term memory. Pictorial information is represented in both systems, whereas a word or sentence is only encoded verbally, and the more representations in memory, the more easily information can be recalled.

Memory for the CFT undoubtably involves *mental imagery*.This can be defined as "a mental representation of a non-present object or event" (Solso, 1991; pp 136).

Kosslyn's (1981) model of long-term imagery describes a number of processes which act upon LTM images. *Generation* creates an image in the visual buffer (the locus of mental imagery where images are created) from LTM. *Inspection* operates on the visual buffer to identify parts of the image. Finally, *transformation* actively alters images within the buffer when necessary (eg. in mental rotation). During recall trials of the CFT, subjects *generate* the complex figure in the visual buffer, and *inspect* or *transform* the image in order to attempt a copy on paper. Farah (1984) suggests that brain injury could interfere with these imagery processes by impairing any of the structures involved in LTM or imagery. For example, TBI subjects who perform below average on the CFT may have generation or inspection deficits in mental imagery, or more general LTM difficulties.

FORGETTING

It is obvious that memories decline over time, and various theories have arisen to explain why.

Decay theory postulates that memories that are not used or rehearsed deteriorate passively over time (Bourne et al., 1986). If memory involves a change in a central nervous system pathway, then disuse will cause this pathway to fade (Solso, 1991). This fairly simplistic view has given way to theories which take account of the influence of activities which intervene between learning and recall.

Interference theory states that memories are held so long as competing information does not interfere with them. Two kinds of interference are recognized: *retroactive interference*, where new memories interfere with old ones, and *proactive* *inhibition,* which describes the effect old material has on new memories. Research demonstrating the power of interference was performed by Jenkins and Dallenbach (1924, in Bourne et al., 1986). In this experiment subjects memorized lists of nonsense syllables; some immediately went to sleep for a certain amount of time, while others carried out normal activities for a similar period. Those who went to sleep had greater recall at four different time periods.

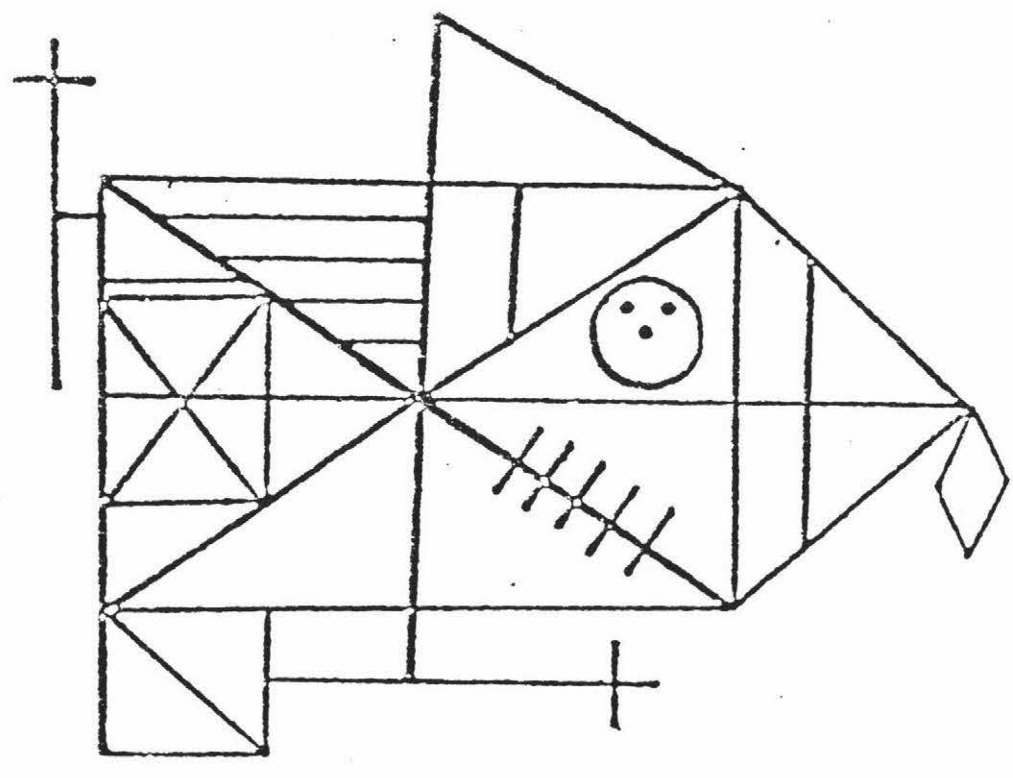
Cue-dependent theory, developed by Tulving (1983), proposes that forgotten information may in fact be available, but the retrieval cues being used do not match the encoded nature of the memory. Tulving also developed the idea of "encoding specificity", whereby cues are effective to the extent that the cue was present when the event occurred (Bourne et al., 1986).

Prolonged loss of memory is termed **amnesia** and takes two forms: *anterograde* and *retrograde* amnesia. *Anterograde* amnesia is impairment of new learning ability, and is a disoder of encoding information. *Retrograde* amnesia is impairment of memory for events which occurred before the onset of amnesia and this is a retrieval disorder (Shimamura, 1989). Amnesia is usually "patchy", some events being remembered and others not (Kolb & Whishaw, 1990). Amnesia is also selective in the type of memory lost,with declarative memories being impaired, and procedural memories being spared (Shimamura, 1989).

CHAPTER 4: THE REY COMPLEX FIGURE TEST

The Complex Figure Test (CFT) was developed by Andre Rey in 1941 as a differential diagnostic tool for mental retardation. The complex figure was presented to the subject who was asked to copy it onto a blank sheet of paper, changing colours several times to record the progression used.

Figure 1: The Complex Figure Test.



Normal adults, according to Rey, tend to copy the complicated design in an analytical way, beginning with elements that make up the figure's structure (central armature) then adding to this background the remaining details in some ordered progression. This analysis makes the copying and later recall of the design easier and quicker. In diagnosing mental retardation, Rey looked for an approach to the task similar to that of a child's (Visser, 1973):

> They start with a detail, and then work little by little, centimetre by centimetre. This approach results in a defective copy that bears only a slight resemblance to the original. In effect, these subjects take pains to reproduce the exact proportions. What happens is that small distortions become more exaggerated as the copy progresses. Finally, they cannot close the figure accurately (translated by Corwin & Bylsma, 1993; pp. 4).

Rey gave three levels by which copy performance can be categorized; (1) A precise copy is made in less than three minutes (normal); (2) The copy is made very slowly but the final result is correct (suboptimal strategies); (3) The copy is made very slowly with a poor result (severe distortion). Three minutes after the copy trial is completed, the subject attempts to reproduce the design from memory, this time using only one colour. Rey advises the following method for analysing a recall trial. Points are given for each of the 47 segments of the figure that is present, added up and given a percentile ranking. (47 points = 100th percentile). Recall performance is then compared to copy performance and assigned to one of four categories:

> a) Excellent normal recall (50th to 100th percentile) with excellent approach to copy. No memory problem can be suspected.
>
> b) Normal recall with poor approach to copy trial. Excellent visual memory despite poor organization. The mnestic and analytic abilities of the subject are dissociated.
>
> c) Poor recall with good copy (0 to 40th percentile). Poor visual memory.
>
> d) Poor recall with poor copy. The subject is impaired (translated by Corwin & Bylsma, 1993, pp. 7-9).

OSTERRIETH'S SYSTEM

Paul Osterrieth, a contemporary of Rey's, believed that analysing the organization of only the copy production neglected important information available from comparison of copy and recall trials, and believed that Rey's scoring system had drawbacks. He felt the complexity of the system increased the likelihood of errors, and was very difficult to apply to particularly disorganized drawings. Osterrieth therefore designed a shorter, simpler system (translated in Corwin & Bylsma, 1993) by establishing 18 details which were most often grouped into wholes by subjects. Each element was awarded between 0 and 2 points, making a possible total of 36. This system was designed to allow an examiner to quickly assess a subject's organization in drawing the figure.

Osterrieth standardized this procedure by obtaining normative data from large groups of normal adults, behaviourally disturbed adults, normal children, children with learning and adjustment problems, and smaller numbers of subjects with brain damage. Consequently the system is highly regarded, and has been the mainstay of CF scoring for many years, and the basis of more recently developed scoring systems (Corwin and Bylsma, 1993).

ADMINISTRATIVE ADAPTIONS

Various adaptions have been made to CFT administration and scoring since it's conception. Although Rey and Osterrieth both used only a three minute delay between copy and recall trials, administrators since have used various other time intervals (Lezak, 1995). Usually the interval is between 20 and 40 minutes (Corwin & Bylsma, 1993), and the most common is 30 minutes (Lezak, 1995). However, it appears that if the interval is within one hour it is of little consequence exactly how long it is (Berry & Carpenter, 1992; Meyers & Meyers, 1995). Most clinicians, however, prefer a longer rather than shorter delay, filling the intervening time with administration of other measures.

Instead of altering time intervals on the CFT, Meyers and Lange (1994) aimed at strengthening it by adding a **recognition subtest.** This involved following recall trials with instructions to circle which of a number of figures were present in the original complex figure. Points are given for figures correctly identified as present on the original or correctly identified as not present. Meyers and Lange (1994) found that the recognition subtest combined with the CFT provided good discriminant ability for normals, and mild to severely impaired brain-injured subjects, adding to the diagnostic utility of the test.

CLINICAL APPLICATIONS OF THE COMPLEX FIGURE TEST

Although the CFT was originally designed for use with mentally retarded patients, it is now most often used to assess memory impairments in people with TBI, as this measure has been shown to discriminate brain-injured individuals from those without damage. Osterrieth's original normative studies included 43 TBI patients, many of whom scored "significantly low" (Lezak, 1995). Subjects with moderate to severe injuries performed at a much lower level than those with mild injury. Binder (1982) also found that brain injured individuals performed less accurately on the test than normals, and noted that subjects with right-brain damage exhibited more severe distortions than those with left-brain damage.

Most clinicians agree that much can be learned from quantitative measures of CFT performance, but valuable information is also gained during an administration by watching how the subject goes about making the drawing. Various researchers have found that organization strategy positively correlates with accuracy of Rey CFT reproduction on delay trials (Bennett-Levy, 1984; Binder, 1982; Giarratano & Tate, 1993; Hamby, Wilkins & Barry, 1993; Heinrichs & Bury, 1991; Klicpera, 1983). TBI patients appear to copy the complex figure in a disorganized manner (Binder, 1982; Giarratano & Tate, 1993; Visser, 1973), and this difficulty in organization was described in the following way by Visser (1973):

> "brain-damaged subjects deviate from the normals mainly in the fact that the large rectangle does not exist for them... [therefore] the main lines and details are drawn intermingled." (pg. 23).

Theories of memory, as described in chapter 2, indicate that memory disorders can be linked to problems with attention, encoding or retrieval. Therefore it follows that those with brain damage either do not encode elements of the CFT in a meaningful way, or do not recall adequately encoded material. It appears that TBI patients do have an encoding problem, and this involves an inability to perceive the CFT as an integrated form. Giarratano and Tate (1993) provided TBI subjects with an organized approach to the CFT by systematically presenting broken down segments of the figure, and found that as a result the TBI subjects' recall accuracy was equivalent to those of non-brain damaged controls. It appears then that TBI patients score lower on recall because they experience difficulty in organizing elements of the Rey CFT, and are unable to encode the information effectively.

The CFT has also been used in the analysis of constructional strategies in patients with Alzheimers disease, alchoholism and dyslexia (Tupler, Welsh, Asare-Aboagye & Dawson, 1995), acquired immune deficiency syndrome AIDS (Duley, Wilkins, Hamby, Hopkins, Burwell & Barry, 1993), stroke patients (Binder, 1982) and schizophrenics (Heinrichs & Bury, 1991). Osterrieth's original normative studies showed that the CFT was appropriate for use with young children, and a scoring system sensitive to children's developmental levels was designed by Waber and Holmes (1985, 1986). The CFT also has diagnostic value when applied to aged samples (Berry, Allen & Scmitt, 1991).

The present study was designed to examine the CFT organization used by a large number of TBI patients and their resulting accuracy. There are many methods of scoring an individual's organization on the Rey test, and the following section summarizes a selection of these, also evaluating each for suitability for use in the present study.

SCORING ADAPTIONS

Although Rey himself proposed in his 1941 article to "examine all the processes involved in making the copy (translated by Corwin & Bylsma, 1993)," he and Osterrieth fell short of achieving a satisfactory measure of these processes. Ever since, researchers have attempted to develop acceptable alternatives. Some systems were designed to measure specific subject performance characteristics and are therefore limited in scope, while others have extensive utility. The wide range of available scoring systems is testimony to the innumerable diagnostic uses of the test. Researchers have either selected an appropriate system from those available, or formulated a new one suited to the task at hand.

Binder (1982)

L. M. Binder (1982) designed a straight-forward system to compare information-processing strategies in left and right hemisphere damaged subjects. The first score consisted of the traditional 18-element accuracy score. The second, "configural" score was the first use of perceptual clustering as a measure of strategy, and is considered an important advancement (Shorr, Delis & Massman, 1992). Binder selected 5 elements that could be drawn either as one unit or fragmented into separate parts. These elements made up the structural base of the figure : the large rectangle, diagonals, horizontal and vertical midlines and the sides of the triangle at the right. In order to score a configural point the subject had to draw an element as one continuous line. If not, it was scored as fragmented, and if not drawn at all; missing.

Despite being something of a breakthrough, Binder's system has limitations, as only a small number of very basic elements are used, confining the system to limited diagnostic power. The all-or-none characteristic of the correct\missing\fragmented administration has also led to criticism (Hamby et al., 1993; Shorr et al., 1992).

Bennett-Levy (1984)

A much more complex system stemming from the Osterrieth model was published two years later by Bennett-Levy (1984). This system was aimed at analysing functional deficits in individual cases.

Copy performance was scored in the traditional way, but recall was measured using two methods. A *strict* score was given in the same manner as the copy score. A *lax* score was made up of the presence and completeness of the elements (scored again as in the copy method), and distortion and misplacement. The latter two were included for the following reasons. First, subjects do not appear to give the same care to recall trials as they do to copy trials, and this is not perceived by Bennett-Levy as a memory problem. Second, recall trials are generally scored less stringently than copy trials. Therefore the distortions and misplacements in the recall trials were scored less strictly.

Recall performance was rated in two more ways. A line had good *continuation* if it was drawn as a single unit and intersected correctly with other lines. The *symmetry* of the recall trial was scored next, based on the assumption that the order in which elements appear reflect the symmetry of the figure as it appears to the subject. The highly complicated process which results in a symmetry score is best summarized by Lezak (1995):

> A symmetry score measures the number of instances (out of 18) in which the symmetry of mirrored elements is preserved, with higher scores when natural components of a symmetrical element are drawn successively (pp. 575).

Good continuation and symmetry are summed to give a strategy total.

Bennett-Levy (1984) found that the two scores and their "strategy" combination were predictive of later recall performance. Despite the specification that the system is designed for individual cases, the procedure is very extensive, calling for the often repeated scrutiny of every line. The complexity of the task may be detrimental to interrater reliability if a large number of subjects were to be rated, and while the author reported high reliability figures for the accuracy score, data regarding continuation and symmetry were not given. Using this system for the hundreds of subjects in the present study would be a huge task and possibly psychometrically unsound.

Klicpera (1983)

Klicpera (1983) wanted to investigate the difference between the ability of dyslexic and normal children to perform complex visuomotor tasks, and, recognizing that the quality of a subject's organization is important, designed a detailed analytical procedure to measure it.

The traditional accuracy score was used, followed by three others. The *presence* of certain elements was determined, distinguishing between the external configuration, main rectangle, internal structure, and details (internal and external). *Organization* was assessed by evaluating; (a) intersections (the number of copied lines at intersections); (b) alignments (of the large rectangle's elements and the diagonals); and (c) arrangement of details (the number of times elements are unnecessarily redrawn or misplaced). The final scoring category, *approach while drawing,* is particularly concerned with the subject's strategy. First, a total is made of the number of parts making up the external configuration, large rectangle and inner structure which are drawn before the inner details, and the number of external details drawn before the external configuration. Second, *continuity* is determined by calculating which of the large rectangle and diagonal lines were drawn continuously. Finally, *segmentation* involves the number of parts drawn in an incorrect position.

Klicpera (1983) was able to differentiate dyslexic children from normals through this system as was hoped. However, like the systems described above, its complexity is a drawback. Also, no interrater reliability figures were reported.

Shorr, Delis & Massman (1992)

Shorr et. al. (1992) recognized the value of the perceptual cluster score first used by Binder (1982), and developed it further by providing a much more detailed scoring system. The first of this system's four scores was the traditional Osterrieth accuracy score. The second was the perceptual clustering score, the "clusters" being the large rectangle, diagonals, horizontal and vertical midlines, the sides of the triangle to the right, the small rectangle and its diagonals, and the small square at bottom left. A point is given if a line that could be broken into separate parts is drawn as a continuous line. Additionally, Shorr et. al. (1992) controlled for constructional ability by dividing the recall score by the copy score to give an *encoding* score. This gave an indication of whether a person's low performance was due to memory or construction problems. The final score took this idea a step further and divided the delay score by the recall score to give a *savings* score, discriminating between a long-term storage problem and a more immediate memory problem.

The authors found that the level of perceptual clustering during the copy trial was a better predictor of later recall performance than copy accuracy, and while encoding was highly correlated with perceptual clustering, savings did not correlate well with either copy accuracy or encoding. It was speculated that this was due to encoding and savings being dependant upon independent cognitive processes. Shorr et. al. (1992) succeeded in improving Binder's perceptual clustering score, and it could easily be used in the present study, but, like Binder's system it still only focused on a single measure of strategy.

While most systems are based upon or are at least derived from the Osterrieth example, some authors have dispensed entirely with this, and the following two methods have more original designs.

Waber and Holmes (1985, 1986)

Waber and Holmes (1985, 1986) designed their system to be sensitive to the developmental levels of children. The CFT records of 454 children were analysed to determine the most important features of the design. From the results came a system which included an accuracy score and two others pertaining to strategy. *Organization* was rated through five levels; the higher the level reached the more points attained. *Style* was evaluated by examining the large rectangle, diagonals and horizontal and vertical midlines, and style performance was rated as either part-oriented, configurational, or intermediate.

This system is quite comprehensive, being constructed by almost exhaustive statistical procedures, and proved to be very sensitive to developmental levels. Interrater reliability was reported as being very high. The obvious problem, of course, is the complexity of the procedure, which requires detailed and repeated scrutiny of each line, and different scoring methods for copy and delay trials. All subjects in the present study are adults, and therefore this system, designed to reflect developmental changes, would be inappropriate without major changes.

The Boston Qualitative Scoring System (1994)

A very recent addition to the collection of systems is the Boston Qualitiative Scoring System developed by Stern, Singer, Duke, Singer, Morey, Daughtrey and Kaplan (1994). This system provided clear guidelines on scoring procedures covering aspects including the presence and accuracy of the main configuration, clusters and details. Scores also were given regarding fragmentation, planning, reduction, vertical and horizontal expansion and rotation. This appears to be the most appropriate of all the systems, being quick and simple and covering all aspects of CFT organization. Unfortunately, while a first edition of the manual for this system has been printed, its authors have experienced a number of difficulties with its use, and therefore declined our request for a copy.

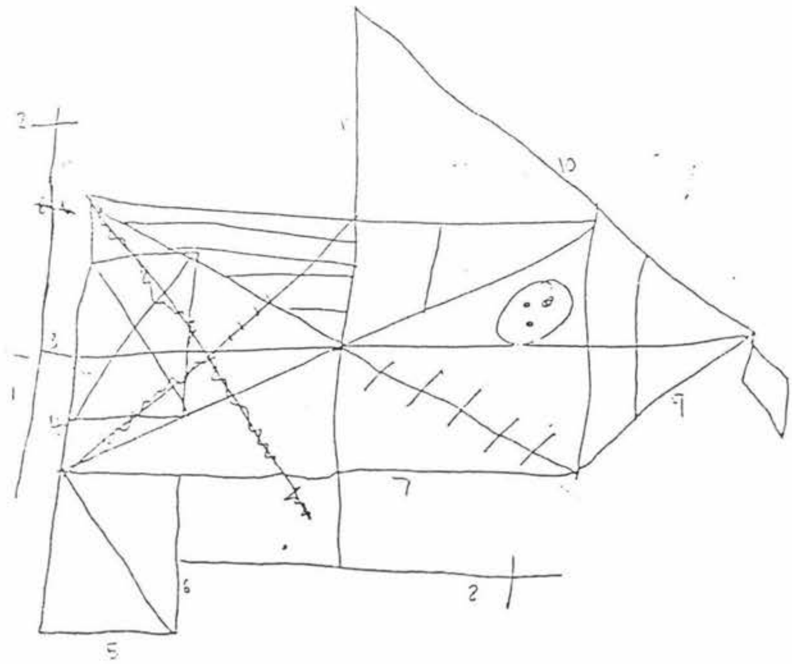
Hamby, Wilkins & Barry (1993)

Comparing some of the existing systems, Hamby et. al. (1993) recognized some common difficulties and attempted to correct them with their own system. It was designed to have five characteristics; (a) high interrater reliability; (b) ease of use; (c) no need for precise records of each line drawn; (d) high construct validity; and (e) applicability to both the Rey-Osterrieth and Taylor CFT tests (although only the Rey-Osterrieth CFT will be described here).

This system again was based upon the Osterrieth model, and relied on the use of various coloured pens switched at approximately equal points during trials. From this the examiner judged the order in which certain elements were drawn.

First the configural elements, consisting of the main rectangle and horizontal and vertical midlines, are evaluated. Points are deducted if these are inaccurate, and also if any detail elements have been drawn before the configural elements. If at this point a low score has already been reached, the scoring stops. Figure 2 shows an example of a copy trial scoring low organization.

Figure 2: Copy trial obtaining low organization



If, however, a moderate score has been reached, the main diagonals are also evaluated as configural elements. If, on the other hand, no mistakes have by now been made, the detail elements are then scored for organization, with only minor point reductions. A subject receives a score of between 1 (low organization) and 5 (high organization). The copy trial was scored using three categories of measures. *Configural* elements included the large rectangle and the horizontal and vertical midlines. Various mistakes involving these lines were measured according to specific instructions, including accuracy and continuation of lines. *Secondary* mistakes involved the diagonals, and were also rated according to accuracy and continuation. Remaining elements were regarded as *details,* and mistakes were made by (a) unnecessary segmentation, (b) not drawing lines consecutively, and (c) redrawing elements. Common detail mistakes were listed as a guide.

In evaluating the construct validity of the system, Hamby et. al. (1993) reported significant correlations between the organization quality scores and three other measures of performance: Copy score, delay score and percentage retained (delay\copy), although the correlation with the important copy score has been criticized as being modest (Lezak, 1995).

This system was selected as the most appropriate CFT organizational measure for use in the present study for the following reasons. Most of the developers' original criteria were met by this system: It was quick and easy to use, interrater reliability was high, and it only required different coloured pens for encoding a subject's strategy. The authors provided similar systems for both the Rey-Osterrieth and Taylor tests, although they found that the two tests were not completely interchangeable. The system was found to accurately distinguish between symptomatic and asymptomatic human immunodeficiency virus positive patients, and its authors state that it may be useful for evaluating patients with various forms of neuropsychological impairments.

SUMMARY

This chapter has described the Rey CFT, a commonly used measure of perceptual organization and visual memory. Although there have been various adaptions to the test's administration and scoring, the most accepted form of quantitatively scoring it is the Osterrieth method. Research has associated a fragmented approach to the test with lower accuracy scores. Subjects with TBI are one group which has been found to perform below average, and this has been attributed to an encoding problem. The present study was designed to investigate further the relationship between organization and recall on the Rey CFT in TBI patients.

CHAPTER 5: THE PRESENT STUDY

SUMMARY AND OBJECTIVES

Traumatic Brain Injury (TBI) is a very common disorder (Miller, 1993), imposing a substantial cost upon individual victims and the state. Most at risk are males aged between 15 and 24 years who typically sustain their injuries in motor vehicle accidents (Bond, 1986). Classification of TBI injuries involve measurement of coma and post-traumatic amnesia (PTA). While most TBI injuries fall into the mild to moderate category (Giacino & Zasler, 1995), they nevertheless can be associated with negative consequences.

Memory disturbance is the most common outcome reported after TBI by patients and their families (Bond, 1986). These problems interfere with everyday functioning and limit independence (Schmitter-Edgecombe et al., 1995). Usually the learning of new information is more affected than learned motor skills and universal memories such as language (Sohlberg & Mateer, 1989).

The Rey Complex Figure Test is commonly used to assess perceptual organization and visual memory after TBI, and research shows that those who adopt an organized approach to the test tend to obtain higher accuracy scores (Binder, 1982; Klicpera, 1983; Bennett-levy, 1984; Heinrichs & Bury, 1991; Hamby, Wilkins & Barry, 1993). Those with brain-injury consistently obtain low accuracy scores on CFT recall trials, and use a more disorganized approach than non-brain injured people (Binder, 1982; Giarratano & Tate, 1993). It appears that this difficulty is due to a problem in the encoding level of processing (Giarratano & Tate, 1993).

The present study aimed at improving on and adding to available research regarding TBI subjects' performance on the Rey CFT. Binder's (1982) study, showing that TBI patients use a more fragmented approach and score lower accuracy, has been described as having a number of limitations, particularly for its use of only five CFT elements in scoring organization (Shorr et al., 1992). Also, only 14 subjects were included in each group. The present research assessed organization using the Hamby, Wilkins and Barry (1993) method, with a large number of subjects than the Binder (1982) study.

Four hypotheses were examined.

Hypothesis 1: *TBI subjects will have significantly lower accuracy scores than control subjects on copy, recall and delay CFT trials.*

The accuracy of the TBI group was compared to the control group across all three trials, with the expectation that TBI subjects would score lower than control subjects on all 3 CFT trials, replicating the results of Binder (1982).

Hypothesis 2: *TBI subjects will obtain significantly lower organization scores than Control subjects on copy, recall and delay CFT trials.*

Binder (1982) also found that TBI subjects make less organized drawings, and therefore the organization levels of both groups were examined in the present study.

Hypothesis 3: *TBI and Control subjects will be consistent with strategy use across all three CFT trials.*

Important to this study was the relationship (examined in hypothesis 4) between a subject's strategy score on the copy trial and their subsequent recall and delay accuracy. Accordingly, the consistency of both groups' organizational approach across the three trials was compared between the TBI and Control groups.

Hypothesis 4: *TBI and Control subjects scoring higher organization on the copy trial will obtain higher accuracy scores.*

Research indicates that organizational approach to the copy CFT trial correlates positively with accuracy in subsequent recall and delay trials (Bennett-Levy, 1984; Binder, 1982; Hamby, Wilkins & Barry, 1993; Heinrichs & Bury, 1991); This was investigated in the present study.

The results of examinations into the above objectives are expected to give a clear indication of the relationship between TBI subject organizational ability and subsequent accuracy on the CFT.

CHAPTER 6: METHOD

Subjects

The characteristics of the TBI and control subjects are summarized in Table 1.The TBI subjects were mainly past clients of the Psychology Clinic situated at Massey University.

Table 1: Characteristics of Group Participants.

	TBI		CONTROLS	
GENDER	(*N*)	(%)	(*N*)	(%)
Male	82	78.1	40	67.8
Female	23	21.9	19	32.2
TOTAL	105		59	
AGE	*Years*		*Years*	
Mean	30.9		30.9	
SD	10.6		10.7	
Range	16-62		17-66	
ETHNICITY	(*N*)	(%)	(*N*)	(%)
European	86	81.9	40	67.8
Maori	17	16.2	17	28.81
Polynesian/Asian	1	1.9	2	3.39
EDUCATION (at testing)	*Years*		*Years*	
Mean post-primary	3.48		4.6	
SD	1.85		2.44	

The control group consisted of inmates from a local prison and clients at an unemployment service. These subjects were chosen to match typical TBI subjects on demographic variables such as age, education and ethnicity. Prison inmates who had experienced moderate to severe head injuries were included in the TBI group.

The most common causes of TBI in the experimental group were motorcycle accident (59.38%) and automobile accident (29.17%). There were also small numbers of falls (4.17%), assaults (4.17%), sporting (2.09%) and industrial (1.05%) accidents. Information regarding the cause of head injury for 9 subjects was unavailable. Most experimental subjects' injuries were moderate or severe as measured by post-traumatic amnesia (PTA), while a few were mild, undergoing assessment not because of particular post-injury side-effects, but simply because they had sustained injuries.

Ethical considerations

All the usual ethical conventions were adhered to when the original interviews were conducted. The nature of the study was explained to participants. Each was given a form containing information regarding the research, and the researcher's telephone number in case of subsequent questions. Only those who gave informed consent were included in the study, and it was made clear that participants could withdraw from the experiment at any time. Confidentiality was assured and practised during all stages of the research process. Files were converted to numerical codes and were only available to persons directly involved in research.

Measures

Two measures were used to assess accuracy and organization. The traditional Osterrieth system was used for accuracy, and the Hamby, Wilkins and Barry (1993) system was used to score organization. The working details of these systems were described in Chapter 4, and so the following will briefly describe the test characteristics of each system.

Osterrieth's System.

Significant age effects have been found on recall trials (Lezak, 1995), with a steady decline in performance beginning in the 30s and dropping sharply in the 70s (Spreen & Strauss, 1991). Men appear to perform better than women, with an average advantage of 1 to 2 points (Bennett-Levy, 1984). Interscorer reliability is very good (r = .91 to .98) (Berry, Allen & Schmitt, 1991; Shorr et al., 1992).

Hamby, Wilkins and Barry (1993).

The authors report high interrater reliability for this measure (r = 87.6), and the rating of each protocol typically took less than one minute. The authors suggest that subjects record their own strategy by changing the colour of their writing implement five times, but this could be viewed as invasive to the subject's progression. In almost all cases in the present study the examiner recorded the subject's progression by making a duplicate copy with each line numbered in order. This measure gave a score of between 1 (for low organization) and 5 (for high organization.

Procedure

The CFT records were from files at Massey University's Psychology Clinic, partly from assessment of current and former clients, and partly from control subjects of past research projects. These records had been scored using the Osterrieth system previously, but they were rescored to ensure interrater reliability, since the examiner was also assessing records for organization using the Hamby, Wilkins and Barry (1993) system, which was scored afterward.

CHAPTER 7: RESULTS

Hypothesis 1: *TBI subjects will have significantly lower accuracy scores than control subjects on copy, recall and delay CFT trials.*

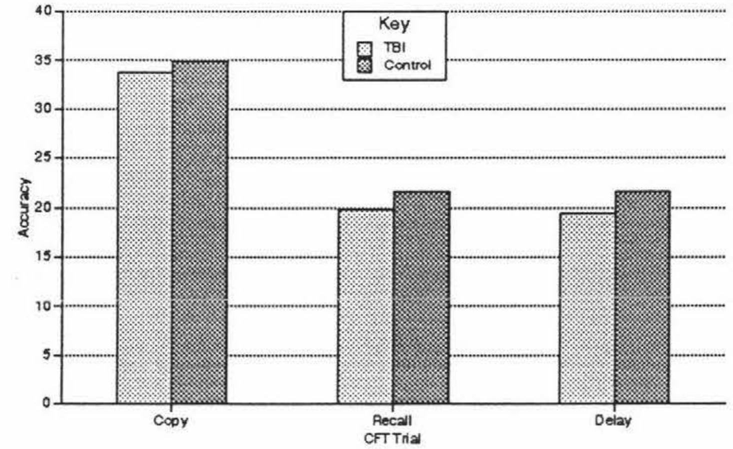
T tests for independent samples were used to calculate whether differences between TBI and control group accuracy (measured by Osterrieth's system) was significantly different across the three trials. Results as shown in Table 2 and Figure 3 provide partial support for Hypothesis 1, with the TBI group scoring significantly below the control group on copy and delay trials.

Table 2: Mean accuracy scores for TBI and Control subjects on copy, recall and delay CFT trials.

	TBI		Control		*t*
	Mean	*SD*	*Mean*	*SD*	
Copy	33.8	3.3	34.9	2.0	-2.38**
Recall	19.8	6.5	21.7	6.6	-1.67
Delay	19.5	6.2	21.7	6.2	-2.12*

* Significant at 0.05 level
** Significant at 0.02 level

Figure 3: Mean accuracy scores for TBI and Control groups at 3 CFT trials.



Hypothesis 2: *TBI subjects will obtain lower organization scores than Control subjects on copy, recall and delay CFT trials.*

Table 3 shows the results of non-parametric (Mann-Whitney *U*) comparison of the mean organization scores of the two groups, on copy, recall and delay CFT trials.

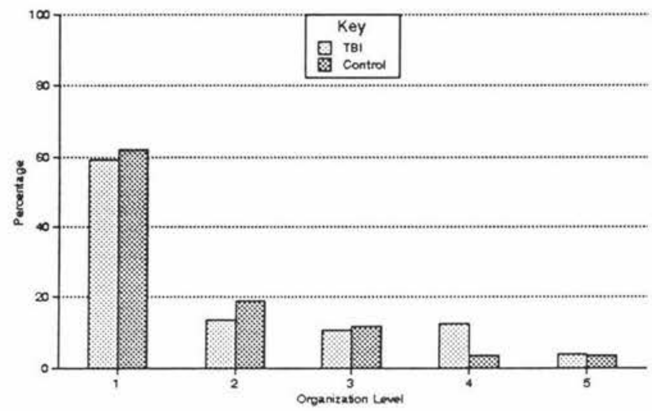
Table 3: Mean organization scores of TBI and Control subjects on copy, recall and delay CFT trials.

	TBI		Control		*U*
	Mean	*SD*	*Mean*	*SD*	
Copy	1.9	1.2	1.7	1.1	2734 (*NS*)
Recall	2.1	1.3	1.9	1.2	2602 (*NS*)
Delay	2.0	1.2	1.8	1.2	2460 (*NS*)

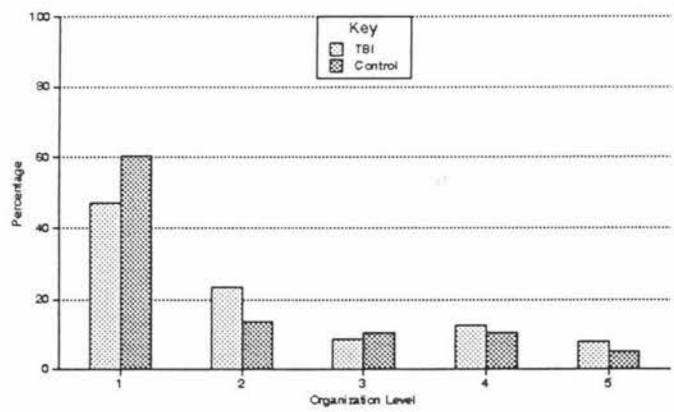
It was expected that TBI subjects would score significantly lower than Control subjects for organization, but the results did not confirm this. In fact, TBI subjects scored slightly higher organization on all three trials (ie. used better organizational style). These differences, however, were not statistically significant. Figure 4 below displays the proportion of TBI and Control subjects scoring in each of the 5 organizational levels for copy, recall and delay CFT trials.

Figure 4: Proportion of TBI and Control subjects scoring in each of 5 organization levels, on copy, recall and delay CFT trials.

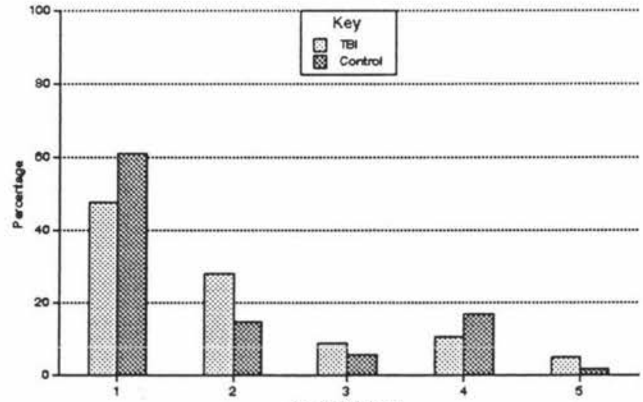
Copy



Recall



Delay



Hypothesis 3: TBI and Control subjects will be consistent with strategy use across all three CFT trials.

As expected, both groups were consistent, with 46 (44%) TBI subjects and 34 (57%) Control subjects maintaining the same organizational approach across all three trials. The remainder changed score at least once. Table 4 shows the proportions of each group changing to a higher or lower organization rating between the copy and recall trials, recall and delay trials, and copy and delay trials.

Table 4: Change of strategy: Proportions of TBI and Control groups changing between CFT trials.

	TBI (N=105)		Control (N=59)	
	Higher	*Lower*	*Higher*	*Lower*
Copy/Recall	30	15	10	8
Recall/Delay	9	19	8	4
Copy/Delay	24	18	11	7

There is a trend for TBI subjects to be less consistent than Controls, receiving varying organization scores across the three trials more often.

Hypothesis 4: *TBI and Control subjects scoring higher organization on the copy trial will obtain higher accuracy scores.*

Table 5 shows the comparisons in accuracy scores for TBI subjects scoring low (1) organization on the copy trial with those scoring higher levels (2-5) of organization. Table 6 displays the same results for Control subjects. These results are displayed graphically in Figure 5 below.

Table 5: Mean accuracy scores of TBI subjects obtaining low (1) and high (2-5) copy organization levels.

	Low Org.		High Org.		*t*
	Mean	*SD*	*Mean*	*SD*	
Copy	33.07	3.82	34.86	2.1	-3.2
Recall	18.67	7.36	21.82	4.3	-2.7
Delay	17.61	6.48	21.92	3.8	-4.16*

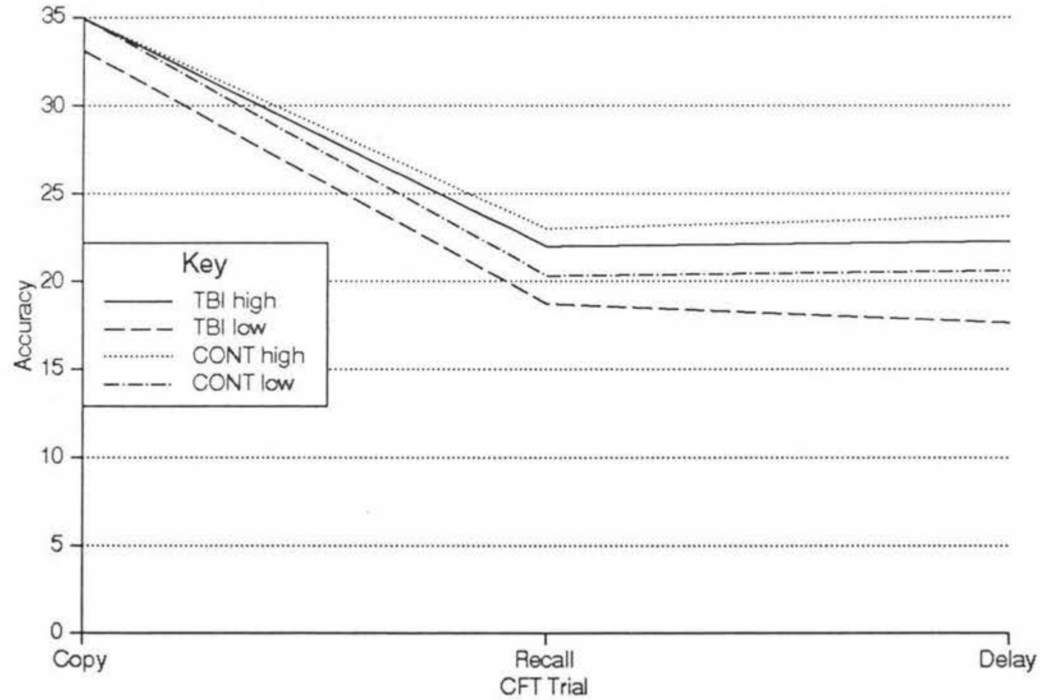
* Significant at .001 level.

Table 6: Mean accuracy scores of Control subjects obtaining low (1) and high (2-5) copy organization levels.

	Low Org.		High Org.		*t*
	Mean	*SD*	*Mean*	*SD*	
Copy	34.85	2.1	35.14	1.6	-.10
Recall	20.25	6.7	20.73	5.5	-1.62
Delay	20.59	6.7	21.95	4.7	-1.98

These results show that TBI subjects obtaining higher copy organization scores had an advantage over TBI subjects who obtained low copy organization scores, thereby providing support for hypothesis 4. This advantage is most evident in the delay trial. Another interesting result apparent in Tables 5 and 6 is that there was no significant accuracy difference between TBI subjects scoring higher organization and Control subjects scoring either low organization (copy: t = .02; recall: t = .22; delay:t = .23) or higher organization (copy: t = -.09; recall: t = -.71; delay: t = -1.12). Control subjects do not appear to gain such an advantage from organization, scoring approximately equally for low and high copy organization. TBI subjects obtaining low organization scored lower accuracy scores than Control subjects who obtained similarly low organization.

Figure 5: Mean accuracy scores of TBI and Control subjects scoring high (levels 2-5) and low (level 1) copy organization.



Summary

Table 7 summarizes the mean accuracy scores for TBI and Control groups according to ratings of organization measured by the Hamby, Wilkins andBarry (1993) system.

Table 7: Mean accuracy scores according to ratings of organization (1 = low organization; 5 = high organization).

	Copy		Recall		Delay	
	TBI	*Control*	*TBI*	*Control*	*TBI*	*Control*
1	33	35	16.4	19.5	16.4	19.5
2	34.7	35.1	22.2	24.2	22.5	23
3	34.5	34.5	22.9	24.5	21.5	24
4	35	35.3	23.5	24.3	23.6	25.5
5	35.2	36	23.5	19.1	24.2	20.5
Mean	34.5	35	19.8	21.3	19.5	21.3
SD	2.6	1.9	6.5	7.2	6.4	6.9

There is a clear trend for the control group to have higher means than the TBI group, with means for recall and delay increasing as a function of increasing organization scores. Means for both groups at level 5 (high) organization were based on very small Ns (very few subjects attaining the highest organizational score of 5 (high) for recall or delay trials) and therefore differences between levels 1 and 4 are a more accurate reflection of the relationship. Here an advantage of 7.1 and 4.8 points for accuracy was found for the TBI and control groups respectively in the recall trial, and in the delay trial, 7.2 points for the TBI group and 6 points controls. These results are represented graphically in Figure 6.

Figure 6: Mean accuracy scores of TBI and Control subjects at 5 organization levels, in copy, recall and delay trials.

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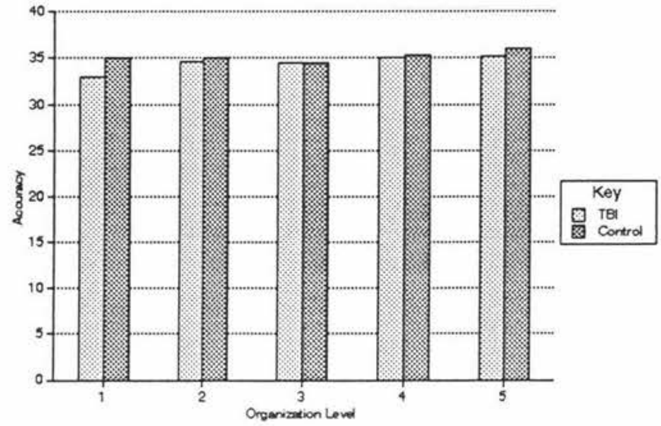
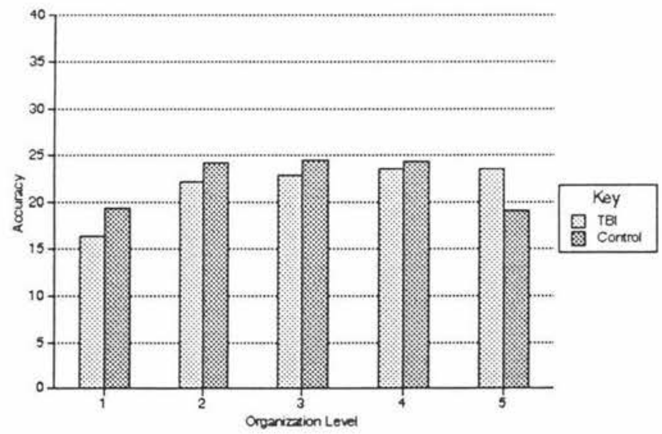
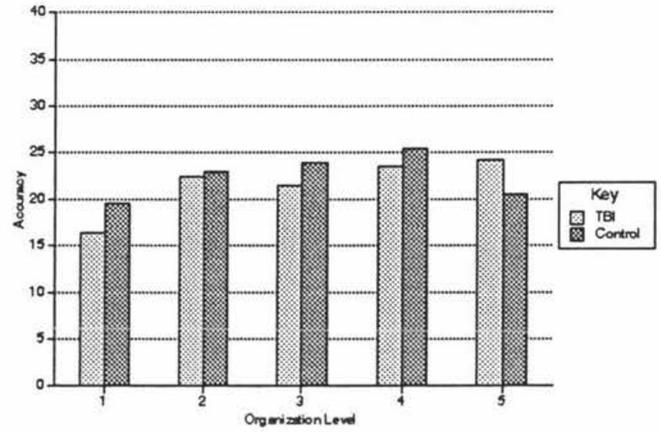


Recall



Delay



CHAPTER 8: DISCUSSION

The present study compared the performance of TBI and control subjects on the CFT in terms of accuracy and organization, examined the organizational consistency of both groups, and the relationship between organization on the copy trial and subsequent recall and delay accuracy. This chapter summarizes the results, discusses their implications and makes suggestions for further research.

Hypothesis 1: TBI and Control Accuracy.

Binder (1982) found that brain-injured individuals performed less accurately on the CFT than non brain-injured individuals. In the present study subjects with TBI also obtained lower accuracy scores as measured by the Osterrieth system, replicating Binder's study and thereby supporting hypothesis 1. However, the fact that TBI subjects scored below controls on the copy trial as well as the two memory trials suggests that the difficulty is in the way they draw the CFT.

Hypothesis 2: TBI and Control Organization.

As research had shown that TBI patients copy the CFT in a piecemeal, disorganized fashion (Binder, 1982; Giarratano & Tate, 1993; Visser, 1973), it was expected that in the present study the same would be found (ie. the TBI group would obtain lower scores than the control group on the Hamby, Wilkins and Barry (1993) organizational scoring system). However, no significant difference was found. Subjects with TBI scored higher for organization than Controls for all three CFT trials. There are a number of probable reasons for this divergence, and these will be discussed later in this chapter, as they relate to all areas of the present study.

Hypothesis 3: Consistency of Organization.

Both TBI and Control subjects were expected to be relatively consistent in organizational approach used across all three trials, and this was confirmed by results. If a subject scored 1 for copy organization they generally scored 1 for recall and delay organization as well. While these results indicate that subjects scoring consistently approached each level with a similar organizational quality as measured by the Hamby, Wilkins and Barry (1993) system, they do not necessarily suggest that subjects used an identical organizational approach in every trial. Some subjects may have changed approach between trials yet retained the same organization score. Nevertheless, subjects were consistent enough to support hypothesis 3, and to show that copy organization generally reflected organization performance overall.

Hypothesis 4: Copy Organization & CFT Accuracy.

Having established that subjects remain consistent in organizational approach, it was possible to examine the relationship between copy organization and subsequent accuracy in recall and delay trials. Various researchers (Bennett-Levy, 1984; Binder, 1982); Giarratano & Tate, 1993; Hamby, Wilkins & Barry, 1993; Heinrichs & Bury, 1991; Klicpera, 1973) have reported that organizational strategy correlates positively with recall and delay accuracy. Results from the present study showed that only TBI subjects gained a significant advantage from better organization. The fact that TBI subjects who scored low organization obtained lower accuracy suggests that these subjects may be impaired in this area, even though they did not average lower organization than Control subjects overall. Farah's (1984) suggestion that TBI interferes with imagery processes (such as generation and inspection) by impairing structures involved in long-term memory may account for the difficulty experienced by TBI subjects.

To summarize, TBI subjects were less accurate than Control subjects on all three trials of the CFT, but did not obtain lower organization scores than control subjects in any of the three trials. Both groups were relatively consistent in their organizational scoring, and higher scores for copy organization were associated with higher recall and delay accuracy, particularly with TBI subjects.

The purpose of the present study was to examine the relationship between TBI patients' lack of CFT organization and their subsequent accuracy on memory trials. However, there was no significant difference between TBI and Control group organization, and therefore it is impossible to speculate on the relationship between TBI subjects' organization and subsequent accuracy on the basis of the results. It is likely that this result was due to methodological limitations inherent in the population samples and the measure used to score organization.

METHODOLOGICAL PROBLEMS.

Sample Populations.

Neither the TBI group nor the Control group can be viewed as truely representative of their target populations. The TBI subjects seen at the Massey University Psychology Clinic were not typical of head-injured people as a whole.

These subjects had attended the clinic predominantly because they had been identified as having residual memory problems and many were seen several years after their injuries. Although these subjects did score below Controls for accuracy, this result may have been more pronounced for TBI subjects in an earlier post-accident period.

The mean accuracy scores for the control group were below norms provided by Spreen and Strauss (1991), suggesting that the control group was also not a true representation of the population at large. Controls had been chosen to match experimental subjects as closely as possible on a number of demographic variables such as age and education, and consisted partly of prisoners and partly of clients of an unemployment centre. While they matched the typical head-injured subject demographically, they cannot be regarded as an accurate general population sample. This may have acted to lower the difference between TBI and Control subjects.

The Hamby, Wilkins & Barry (1993) measure.

The fact that TBI subjects did not score lower than controls for organization can be attributed partly to limitations of the organizational measure. While the criteria such as speed and ease of use were met, the ability to detect subtle differences in organization appears to have been sacrificed. Most subjects in both groups scored 1 for low organization. This could be partly due to the unrepresentativeness of the matched population samples as described above, but a significant difference was found between these groups for accuracy, so sample unrepresentativeness alone cannot account for the organization results. Further, since Hamby, Wilkins & Barry (1993) do not provide normative data it is difficult to determine how TBI and Control subjects should score. Therefore it would appear that either the TBI subjects do not have an organizational problem, or that the organization measure was unable to distinguish between TBI and Control subjects. The former scenario is unlikely, since many researchers have found TBI subjects to have organizational difficulties with the CFT, and the fact that TBI subjects in the present study scored lower accuracy than Control subjects even in the copy trial indicates that they do have a problem in this area. Therefore the latter possibility is more likely: That the Organizational measure was unable to detect the differences between TBI and Control subjects' organizational strategy.

One possible reason for most subjects scoring low organization is that the system may categorize a subject in this way too soon. For example, the first step in the Hamby, Wilkins and Barry categorization is to determine the presence or absence of the configural elements, and scoring to a large extent reflects this step. The order in which the various details are drawn receives only secondary attention, and small point allocations. A more accurate reflection of organization may perhaps be gained if more attention was given to the addition of detail elements to the configural background. A system such as the Boston Qualitative Scoring System (Stern et al., 1994) may be a more appropriate system, covering more aspects of CFT organization, but unfortunately it is not currently available.

FUTURE RESEARCH.

TBI has become a major problem for Western society, and while memory deficits are one of the most common resulting difficulties, the precise nature of these deficits is not fully understood. The CFT is commonly used to assess TBI patient's planning and organizational skills, and researchers have sought a method of qualitatively scoring a subject's organizational approach. The present study used one organization measure to compare TBI and Control use of strategy, but found that the measure was unable to accurately distinguish between levels of organizational quality. Most subjects scored low organization, suggesting that the system relegates a subject to this score too quickly. The population samples were seen as another limitation of the study, both TBI and Control groups being inaccurate representations. It appears that if more representative populations were combined with a more comprehensive organizational measure, the results would contain more information regarding the relationship between TBI patients' use of organization and their subsequent accuracy on the CFT.

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