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A comparison of metamemory judgements and forgetting rates for item and associative recognition for normal and closed-head injured populations

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A COMPARISON OF METAMEMORY JUDGEMENTS AND FORGETTING RATES FOR ITEM AND ASSOCIATIVE RECOGNITION FOR NORMAL AND CLOSED-HEAD INJURED POPULATIONS

By

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I would like to dedicate this thesis to my parents, Rampersad and Sumintra Gopeesingh, who have always given me their unconditional love, support, and encouragement to pursue my goals and to realize my potential.

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Abstract

Metamemory, in particular memory monitoring during a memory task, was investigated in a closed-head injured (CHI) population and a normal (control) population. Prediction ratings were used to determine memory monitoring at time of encoding, and postdiction ratings were used to determine memory monitoring at time of retrieval. Item and associative information for concrete and abstract words were tested using a forced-choice recognition test procedure. Forgetting rates for these two types of information (item and associative) were examined by analyzing immediate and final recognition memory performance. Results indicated that the CHI group had a lower overall level of recognition performance, however the pattern of performance was similar for both groups. Both the control and CHI group demonstrated the concreteness effect, but this effect was found to be dependent on the type of recognition test and time of test. In particular, the concreteness effect was only observed for associative recognition on the final test. Furthermore, there was a steep decline over time for associative recognition of abstract material; such a consistent pattern of decline has not previously been reported for associative recognition. There was no significant relationship between memory monitoring at time of encoding (prediction) and memory performance for either group, however for the control group (but not the CHI group) there was a significant relationship between memory monitoring at time of retrieval (postdiction) and memory performance. These findings suggest that, for the CHI group, recognition performance for item and associative information is quantitatively but not qualitatively different from that of the control group. Furthermore, findings suggest that there may be a partially preserved ability in the CHI group to exhibit the concreteness effect, depending on the experimental conditions. The significance of these findings are discussed in relation to existing theory and possible implications.

Table of Contents

List of Figures

List of Tables

A COMPARISON OF METAMEMORY JUDGEMENTS AND FORGETTING RATES FOR ITEM AND ASSOCIATIVE RECOGNITION FOR NORMAL AND CLOSED-HEAD INJURED POPULATIONS.

To establish a context for the present study, an attempt will be made to familiarize the reader with the main concepts of metamemory, head injury and forgetting rates for item and associative information.

Metamemory

Definition and Historical Context

The term "metamemory" was coined by Flavell (1971) and refers to "the individual's knowledge of and awareness of memory, or of anything pertinent to information storage and retrieval" (Flavell & Wellman, 1977, p.4). This includes knowledge of mnemonic strategies (e.g., rote rehearsal, verbal elaboration, imagery), the utility of strategies, the amount of effort required to execute particular memory strategies, and memory capacity limitations (Devolder & Pressley, 1989). Although the term "metamemory" has only been in use since 1971, the concept itself is historically much older.

The issue of people's awareness of their memory processes has been documented since the early 1900's

(Baldwin, 1909; Binet, 1903, cited in Cavanaugh & Perlmutter, 1982; Kuhlmann, 1907). These early investigations are relevant in the evolution of metamemory as a construct, and in the techniques used to monitor memory.

Binet (1903) investigated self awareness of problem solving strategies by reporting the "thought" processes revealed by his daughters while solving problems. Kuhlmann (1907) investigated the thought processes involved in "memorizing" and recalling pictures by asking participants to "describe in detail how [they] went about memorizing [a] group [of pictures]" (Kuhlmann, 1907, p. 392). Baldwin (1909) used an introspective questionnaire to determine sixth and twelfth grade children's knowledge about study strategies, self-testing and study time.

These early studies used mainly introspective methods and as a result are questionable because of the subjective nature of this method. There has been some debate regarding the interpretation of introspective data (e.g., Nisbett & Wilson, 1977). However, these studies remain significant because they examine aspects of "thought" (Binet, 1903; Kuhlmann, 1907), strategies, time required for study, and self-testing (Baldwin, 1909). These components have all become central issues in the evolution of metamemory as a construct.

Classification of Metamemory

Flavell and Wellman (1977) proposed a taxonomy of metamemory in which they distinguished between two types of memory knowledge: (1) the *sensitivity* category; (2) the *variable* category. The *sensitivity* category refers to knowledge about the need to employ memory strategies for a particular task. More specifically, it is the knowledge that some tasks or situations require intentional mnemonic behaviour while others do not. For example, when individuals are presented with paired items to learn, the use of mnemonic strategies such as imagery (Paivio, 1971; Rubin, 1980), interactive imagery (McGee, 1980), or verbal elaboration has been shown to result in better performance than rote rehearsal (BharrathSingh, 1992, unpublished). The *variable* category refers to an individual's knowledge that performance in a memory situation is influenced by a number of variables. Flavell and Wellman (1977) subdivided these variables into three components: (1) the person variable; (2) the task variable; and (3) the strategy variable. The person variable is comprised of knowledge about one's own and other's characteristics, limitations and abilities as a memorizer. The task variable includes the characteristics of the materials and the task demands that an individual comes to know. The final component, the strategy variable, corresponds to the individual's knowledge about the utility of mnemonic strategies in the storage and retrieval of information.

Additional categories have been proposed by Paris (1978) and Chi (1983). Paris (1978) has suggested a *sensitivity/coordination* category which would consider and account for modulating factors (i.e., variables that attenuate performance). Additionally, he suggested a *cultural milieu* category to account for the influence cultural backgrounds may have on an individual's cognitive abilities and performance. The cultural milieu category can be considered a further subdivision of the person component of the variable category because of its emphasis on the individual's cultural background.

Most definitions of metamemory include knowledge about one's own memory processes. It is uncertain whether the translation of memory knowledge into efficient processes should be included in the definition of metamemory. Chi (1983) questions whether the conceptualization of metamemory should include a mixture of *declarative knowledge* and *procedural knowledge*. Declarative knowledge refers to factual and verbalizable knowledge about memory, whereas procedural knowledge refers to knowledge about production rules (Chi, 1983; Cohen & Squire, 1980; Shimamura & Squire, 1988). Brown (1978) suggests that what a person knows (knowledge about memory) and how she or he uses it (processes integrating this knowledge) should not both be termed metamemory; she believes a clear distinction should be made. This distinction is significant because a person's knowledge about memory is different from if and how that knowledge is used.

Assessment of Metamemory

Currently, there are two main classes of methods used to assess metamemory: independent measures and concurrent measures (Cavanaugh & Perlmutter, 1982).

Independent measures occur in the absence of simultaneous memory activity; they are introspections made about hypothetical goals and past personal experience. This measure determines what and how much an individual knows about memory, and the relevance of that knowledge to the performance of a particular type of memory task. Independent measures include interviews, questionnaires (Perlmutter, 1978), and pictorial techniques (Wellman, 1978; Yussen & Bird, 1979). A pictorial technique is a nonverbal technique in which a series of pictures is presented (instead of presenting memory problems verbally) (Wellman, 1978). For example, three pictures might be shown, one with an individual trying to learn the names of fifteen people, another with an individual trying to learn the names of ten people and another with an individual trying to learn the names of five people. The participant is asked to make judgements by rank ordering the difficulty of the tasks pictured, from easiest to hardest. These rank orderings are then used to infer memory knowledge.

Concurrent measures occur in the presence of simultaneous memory activity - assessment occurs either in the context of, or during, a memory task. The objective is to determine what knowledge about memory the individual brings to the fore when performing a particular task. Concurrent measures include memory monitoring (Perlmutter, 1978), verbal protocols (e.g., Meichenbaum, Burland, Gruson, & Cameron's, 1982, think aloud technique/probe technique), and reaction time (i.e., the duration of time it takes an individual to perform a task).

Memory monitoring refers to the ability to assess and evaluate current memorial contents and processes (Perlmutter, 1978). Memory monitoring includes several methods: (1) feeling-of-knowing judgements which refer to participants' confidence ratings of items they think they know but cannot generate at the time (Hart, 1965; Nelson, 1988); (2) performance predictions (Lovelace, 1984a; 1984b) which are estimates of how much will be recalled; (3) performance postdictions which are participants' ratings of their confidence in the correctness of their response (Shimamura & Squire, 1988); and (4) recall readiness which involves the determination of whether items have been studied sufficiently to guarantee their recall (Catino, 1976; Flavell, Friedrichs, & Hoyt, 1970). It has been suggested that concurrent measures are preferable to independent measures because they are more objective (Cavanaugh & Perlmutter, 1982). Regardless of whether this suggestion is valid, both independent and concurrent measures can provide useful information and supplement one another.

The Metamemory-Memory Relationship

One of the reasons for the increasing interest in metamemory is the belief that memory knowledge might help explain memory performance. Historically this belief is derived from the supposition that what one knows is related to how one behaves (Gard, 1907; Lindley, 1897). The study of metamemory-memory relationships is concerned with this belief.

Wellman (1983) suggests that the relationship between metamemory and memory performance may not necessarily be strong, even though the two may be related. It has been suggested that factors such as motivation and effort allocation (Flavell, 1978; Flavell & Wellman, 1977; Wellman, 1983) influence, as well as add to, the complexity of the metamemory-memory relationship. By contrast, Brown (1978) believes there is a strong relationship between an individual's knowledge of memory and her/his performance on memory tasks. She considers this to be one of the most convincing theoretical arguments for studying metamemory.

The empirical evidence concerning the relationship between metamemory and memory performance has been equivocal. This inconsistency may be related to the various types of knowledge and memory behaviour studied. For example, studies concerned with the development of organizational strategies (Cavanaugh & Perlmutter, 1982) versus studies that focus on the monitoring aspect of memory (Wellman, 1983) cannot be easily compared. Any comparison would be misleading as the phenomena under investigation are different even though both phenomena are considered to be part of the metamemory-memory performance relationship.

Cavanaugh and Perlmutter (1982) were pessimistic in their evaluations of the metamemory-memory relationship. They reported negative, moderate and low correlations between knowledge of memory and memory performance. Their findings were based on three studies, Brown, Bransford, Ferrara, and Campione (1983), Kelly, Scholnick, Travis, and Johnson (1976), and Salatas and Flavell (1976). A brief review of two of these studies will follow.

Kelly et al. (1976) indicated that there was no obvious relationship between memory appraisal and memory estimation accuracy. They based their conclusion on two experiments involving both children and adults. The first experiment investigated the effects of content estimations (i.e., estimations of recallability of selected items on a list or the entire list [recall readiness]) and time of estimations (i.e., whether estimations were made prior to or after recall) on the accuracy of memory appraisal. Results indicated no obvious relationship between memory appraisal (content and time estimations) and memory estimation accuracy (memory performance) for either age group (i.e., children or adults). The second experiment investigated the relation between predictions of recall and study strategies, recall readiness, and actual recall. Results indicated that children and young adults were equally accurate in their estimations of recall after being tested. Additionally, when the groups had to learn the list to a criterion of perfect recall, adults utilized their initial estimation of recall more efficiently than children in deciding what to study and how long to study. Recall readiness, absolute level of recall, and choice of strategies for studying was unrelated to skill in memory appraisal.

Salatas and Flavell (1976) failed to find a relationship between knowledge (metamemory) and categorical strategy use. They investigated young children's sensitivity to different instructional demands. Children were required to learn a list of words belonging to a specific category (e.g., toys, clothes, tools). The participants in the experimental group were told to do whatever they could to remember the items, while participants in the control group were instructed to simply look at the items and were not told that they would be tested for memory of the items. After participants had studied the list, a retrieval task was administered to determine whether the participant could use the category structure spontaneously in a recall situation that did not explicitly demand its use. The participants were asked one of two sets of questions which sampled items from each category without mentioning the category name (e.g., "What things can be used outside ?" and "Which things are small enough to fit into this box ?"). If the participants answered the questions by searching through the list category by category, then they were questioned about their knowledge of the search procedure they used. Results indicated that the experimental group remembered more items than the control group. However, there was no relationship between knowledge (metamemory) and categorical strategy use.

Schneider (1985) and Schneider and Pressley (1989) also reviewed the literature concerning the metamemory-memory performance relationship. These investigators used a larger number of studies than did Cavanaugh and Perlmutter (1982) and concluded that there was in fact a stronger relationship between metamemory and memory than suggested by the findings reported by Cavanaugh and Perlmutter (1982). Using meta-analytic procedures, Schneider (1985) reported 47 correlations based on 2231 participants from 27 publications. The average correlation coefficient from the individual studies investigating the metamemory-memory performance relationship was 0.41. Additionally, Schneider and Pressley (1989) conducted a meta-analysis, based on 7097 participants from 60 publications, providing 123 correlations. Their results were the same as Schneider's (1985); that is, they obtained the same overall correlation of 0.41. Based on the reviews and meta-analyses of Schneider (1985) and Schneider and Pressley (1989), it appears that Cavanaugh and Perlmutter's (1982) evaluation and conclusion of the metamemory-memory performance relationship may have been premature. Additionally, variations in the tasks used and characteristics of participants in the studies may have contributed to the inconsistency of results. The relative newness of metamemory investigation and the disparity of research findings may be a natural step to more precise definitions of the metamemory phenomenon. Eventually research mav be able to investigate and then accurately compare truly similar aspects of this phenomenon.

Initially most of the literature in the area of metamemory research was conducted by developmental researchers who were concerned with metamemory in children (for reviews see Pressley, Borkowski, & O'Sullivan, 1985; Schneider & Pressley, 1989). Gradually, other researchers focused on the age-related component of metamemory, for example, young versus older adults (Cavanaugh & Poon, 1989; Leowen, Shaw, & Craik, 1990; Perlmutter, 1978). Recently, researchers have investigated the metamemory phenomenon in clinical populations (Janowsky, Shimamura, & Squire, 1989a; McGlone & Wands, 1991; Parkin, Bell, & Leng, 1988; Prevey, Delaney, & Mattson, 1988). Prigatano and Schacter (1991) suggest that metamemory paradigms may provide a useful index of an individual's awareness of memory deficits. Additionally metamemory may be useful in identifying which clinical groups (e.g., amnesic and closed-head injured [CHI] patients) are aware of their memory deficits, and the type of information that underlies such awareness (Prigatano & Schacter, 1991). Also perhaps more information about metamemory in a normal population may be obtained by contrasting metamemory in normal and clinical populations. Furthermore, an investigation of metamemory in a head-injured population may add to the existing research in the clinical literature regarding the role of various brain structures in metamemory ability (Janowsky et al., 1989a; McGlone & Wands, 1991; Parkin et al., 1988; Prevey et al., 1988). Thus, a review of metamemory in relation to a clinical population (in particular a brain-impaired population) is essential.

Metamemory in Clinical Populations

Janowsky et al. (1989a) investigated the feeling-of-knowing phenomenon in patients with frontal lobe lesions and healthy control participants. The performance of these two groups was compared to the performance of patients with Korsakoff's syndrome and non-Korsakoff amnesics. The populations used in Janowsky et al.'s study are of particular interest for a number of reasons. Firstly, Janowsky et al. (1989a) reported that patients with Korsakoff's syndrome and other non-Korsakoff amnesics performed equally poorly in recall and recognition memory tests; however, when making metamemory judgements, Korsakoff patients were impaired whereas other non-Korsakoff amnesics were as accurate as normal participants in their metamemory judgements. This led Janowsky et al. (1989a, p.3) to assert that "impaired feeling of knowing is not an obligatory feature of amnesia." Furthermore, they suggested that the brain structures necessary for metamemory abilities seem to be different from those that when damaged cause amnesia (i.e., the medial temporal and diencephalic structures). It has been suggested that the impaired metamemory abilities of patients with Korsakoff's syndrome may be attributed to frontal lobe pathology (Janowsky et al., 1989a); additionally, frontal lobe atrophy is present in Korsakoff syndrome patients (Carlen, Wilkinson, Wortzman, Holgate, Cordingley, Lee, Huszar, Moddle, Singh, Kiraly, & Rankin, 1981; Jacobson & Lishman, 1987). Given these findings, there is a need to examine metamemory and memory performance in a frontal lobe lesioned population.

Janowsky et al. (1989a) conducted two experiments. In Experiment 1, participants were presented with sentences and asked to recall (cued-recall was used) key words from each sentence. Frontal lobe lesioned patients and the controls exhibited comparable recall and recognition memory performance for words in sentences. After the memory test, individuals were asked to give feeling-of-knowing judgements for the unrecalled items. The feeling-of-knowing phenomenon refers to the ability to predict future success on a memory test (Hart, 1965). Specifically, the participants' feeling-of-knowing judgements were based on how likely they would be to recognize the key words on a subsequent recognition test. In contrast to the control and non-Korsakoff amnesics, frontal lobe lesioned patients overestimated their feeling-of-knowing judgements (as did the Korsakoff's syndrome patients) for sentences when a delay of 1-3 days was imposed between sentence presentation and cued-recall. The frontal lobe lesioned patients' impairment (i.e., overestimation) was based on the number of correctly recognized items that were previously unrecalled. The number of correctly recognized items was found to be lower than the previously predicted feeling-of-knowing judgements.

In Experiment 2 Janowsky et al. (1989a) investigated feeling-of-knowing accuracy for general (factual) information questions. In this task the frontal lobe patients and the control subjects were equally accurate in their feeling-of-knowing judgements. Janowsky et al. (1989a) suggested the better performance of the frontal lobe patients in the general information task may have occurred because the material would have been learned prior to the frontal lobe injury, thus making accurate feeling-of-knowing judgements more likely.

Shallice and Evans (1978) demonstrated that similar frontal lobe patients fail to accurately estimate memory for everyday objects and prices that were familiar premorbidly. This challenges Janowsky et al.'s (1989a) assertion that the premorbid familiarity factor may have influenced performance on the general information task.

Another consideration involves the task characteristics which are different between "sentences" and "general information". Janowsky et al. (1989a) suggest that feeling-of-knowing judgements may have been impaired because the sentence material was arbitrary (e.g., "At the museum we saw some ancient relics made of clay"), and as a result not well related to the person's existing knowledge. The general information, on the other hand, covered a variety of topics that would have been learned long ago, and as a result would be more likely to be integrated into a person's knowledge base.

Overall, Janowsky et al. (1989a) found that patients with frontal lobe lesions and patients with Korsakoff's syndrome exhibited impaired feeling-of-knowing judgements (i.e., they tended to overestimate), while the non-Korsakoff amnesics (like the controls) did not. Frontal lobe lesioned patients exhibited impaired (i.e., overestimated) feeling-of-knowing judgements only for sentences in the delayed condition. By contrast, the Korsakoff's syndrome patients exhibited impaired (i.e., overestimated) feeling-of-knowing judgements for both sentences and factual information. These results led Janowsky et al. (1989a) to suggest that the frontal lobes make an essential contribution to metamemory and that memory and metamemory are dissociable processes. These results are significant to the evolving metamemory construct because of the implication of a possible brain site (i.e., frontal lobes) in the metamemory process.

Janowsky et al. (1989a) suggested three reasons why metamemory deficits found in Korsakoff's syndrome patients might be attributed to frontal lobe pathology. Firstly, patients with Korsakoff's syndrome but not other amnesic patients exhibited cognitive deficits (e.g., impairment on Wisconson Card Sorting Test and Initiation and Perseveration subscale of the Dementia Rating Scale) that were also observed in patients with circumscribed frontal lobe lesions

(Janowsky, Shimamura, Kritchevsky, & Squire, 1989b). Secondly, the severity of some cognitive deficits found in Korsakoff's syndrome patients (e.g., failure to release from proactive interference and poor temporal order judgements) have correlated with performance on tests of frontal lobe function (Squire, 1982). Thirdly, both patients with Korsakoff's syndrome and those with frontal lobe lesions have been observed to exhibit apathy and lack insight into their disorder (Blumer & Benson, 1975; Butters & Cermak, 1980; Luria, 1966; Squire & Zouzounis, 1988; Talland, 1965). The suggestion that memory and metamemory are dissociable processes gains support from Janowsky et al.'s (1989a) findings that recall and recognition memory performance did not differ between frontal lobe lesion patients and controls, whereas metamemory (i.e., feeling-of-knowing judgements) did.

Parkin et al. (1988) used a 28-item questionnaire to compare normal adults and amnesic patients (temporal lobe amnesics and Korsakoff's syndrome) on general knowledge about memory. They defined metamemory as an individual's general knowledge about the functioning of memory (rather than an individual's knowledge of their own memory). There were 14 variables in the questionnaire, based on the Kreutzer et al. (1975) study, with two similar questions that differed only in phrasing for each of the variables. This allowed for an assessment of test-retest reliability.

Results indicated that the amnesic groups (temporal lobe amnesics and Korsakoff's syndrome) performed significantly more poorly on the metamemory knowledge questionnaire than the control group, however there were no differences between the temporal lobe amnesics and Korsakoff's syndrome groups.

Analysis of specific differences (based on proportion of correct answers for each variable) showed that the temporal lobe amnesics and Korsakoff's syndrome groups differed most from the control group in their knowledge of how strategies might improve memory. For example, amnesics seemed to be unaware that categorical relations between items would be an aid to memory, nor were they aware that word pairs consisting of opposite words would be easier to learn than arbitrarily paired words (Variable 6). Parkin et al. (1988) suggested that amnesics may fail to utilize memory strategies because they lack the appropriate basis upon which to devise, or initiate, effective learning strategies. This suggestion gains support from Leng and Parkin's (1988) findings that amnesics were unable to effectively learn paired-associates.

Parkin et al. (1988) also investigated participants' insight based on their evaluations of their own memory performance (Variable 1 in their Experiment[1]). On this

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[1] Parkin et al. (1988) give a summary of Variable 1 in their study as: (1) Memory ability. Do you forget? Are you a good rememberer? Can you remember better than your friends? Are some things easier for you to remember than others?

variable the amnesics obtained a score only if their response was consistent with their amnesic state, that is, the patient would have to acknowledge having poor memory. Thus the higher the score, the poorer the patient's report of their memory. Results indicated that the Korsakoff's syndrome group scored significantly worse (i.e., lower [overestimating their memory ability]) than the temporal lobe amnesic and control groups on evaluation of memory performance. This finding suggests that Korsakoff's syndrome may be associated with a lack of insight (as their report of their memory ability was not consistent with their true state). This finding is consistent with the Parkin (1984) and Janowsky et al. (1989a) studies in which they concluded that Korsakoff's syndrome was associated with lack of insight. Lack of insight has also been associated with temporal lobe amnesics for specific types of memory, for example, visual and verbal (Prevey et al., 1988).

Prevey et al. (1988) investigated perception of memory abilities for encoding and retrieval in unilateral temporal lobe seizure patients (right and left) and normal control participants. Self-monitoring of encoding was measured using a prediction of memory span performance, and self-monitoring of retrieval was measured using a feeling-of-knowing procedure.

For the prediction of memory span, participants were required to estimate as accurately as possible the longest list of words they could recall (verbal memory span), and the longest sequence of designs they could produce (visual memory span). Accuracy of prediction estimates was assessed by testing actual memory span for words and designs.

Results indicated that there were no significant differences between the control and temporal lobe seizure groups (left and right) in accuracy of prediction estimates of verbal memory span. However, there were significant group differences in actual verbal memory performance, with the left and right temporal lobe seizure patients performing more poorly than the control group. There were no significant differences between the left and right temporal lobe seizure patients. Prediction of visual memory span did not differ between the right and left temporal lobe groups. However, the three groups differed significantly on visual memory performance. The right and left temporal lobe patients performed significantly worse than the controls, but there was no difference in visual performance between the right and left temporal lobe patients.

Prevey et al. (1988) also investigated participants' ability to predict whether they would recognize the correct answer to a question when they were unable to recall the information (feeling-of-knowing). Results indicated that temporal lobe seizure patients overestimated their abilities to recognize a piece of information. Thus, in both encoding and retrieval ability, there was a tendency for temporal lobe seizure patients to overestimate their ability, demonstrating a failure to accurately monitor both encoding and retrieval processes. Although there were no significant differences between right and left temporal groups for predictions of verbal and visual memory, Prevy et al. (1988) noted a fairly consistent tendency to overestimate predictions depending on the site of lesion (i.e., whether the lesion was on the left or the right side). For example, Prevy et al. found that left temporal participants tended to be less accurate in estimating actual verbal memory performance, whereas right temporal participants tended to be less accurate in estimating actual visual memory performance. Prevy et al. (1988) concluded that this suggested limited awareness of the nature of their own memory deficits.

In summary, these studies suggest a wide array of metamemorial impairments in brain-impaired populations depending on site of lesion. Essentially there are: (1) impaired feeling-of-knowing judgements for factual information (general and specific) (Janowsky et al., 1989a); (2) impaired general knowledge concerning memory (particularly strategy use) (Parkin et al., 1988); and (3) impaired monitoring of encoding and retrieval processes (Prevey et al., 1988).

McGlone and Wands (1991) investigated self reports of memory functioning by giving the Memory Observation

Questionnaire ([MOQ] Humphrey, McGlone, Gupta, & Evans, 1990) to patients with temporal lobe epilepsy and temporal lobectomy. Reports from the patients' families concerning the patients' memory functioning were used as external means of validating the patients' self reports. In particular, McGlone and Wands (1991) investigated whether removal of brain tissue (temporal lobectomy cases [post-op TL]) resulted in the perception of poor memory function, and whether negative self evaluations would be found in temporal lobe epileptics prior to elective surgery (pre-op TL). They also examined the effect of surgery laterality upon awareness of memory function. There were 31 pre-op TLs, 11 with major seizure localized in the left temporal lobe, and 20 with major seizure localized in the right temporal lobe. There were 72 post-op TLs, 42 had undergone left side resections, and 30 had undergone right side resections. All surgery was done 6 months to 10 years before the study. The control group consisted of 63 healthy volunteers recruited from the community. Results indicated that both the pre-op TL and post-op TL groups perceived their current memory status to be poorer than that of the controls. The pre-op TLs did not differ from the post-op TLs in their self rating of current memory status. However the post-op TLs who had surgery at least three years previously judged their memory to have improved after temporal lobectomy, and this was validated by reports obtained from the patients' relatives.

McGlone and Wands (1991) suggested that the results indicate the crucial factor contributing to a perception of poor memory functioning to be a history of epilepsy, rather than temporal lobectomy, since the post-op TL group did not differ from the pre-op TL group in their judgements of their current memory status. This conclusion seems reasonable because all patients in this study had at one time suffered with epilepsy, the pre-op TL group at the time of the study experienced epileptic seizures, and the post-op TL group prior to having temporal lobectomies experienced epileptic seizures.

Results failed to indicate a laterality effect on the MOQ total scores, but analyses based on subscales of the MOQ revealed that patients with left temporal lobectomies believed their memory for material of a verbal nature to be much worse than did patients with right side lobectomies. This finding has been supported in the research literature (Miller, 1978; Novelly, Augustine, Mattson, Glaser, Williamson, Spencer, & Spencer, 1984). However, McGlone and Wands (1991) did not offer any validating evidence (i.e., reports from patients' relatives) to support this subscale laterality difference.

The McGlone and Wands (1991) study, although not illustrative of an impairment in metamemory ability to monitor memory function for either the pre-op TL or post-op TL groups, can serve as supportive evidence for the Janowsky et al. (1989a) study. If McGlone and Wands' (1991) study is considered as an investigation of general metamemory ability with an emphasis on the temporal brain structure, then the findings partially support Janowsky et al.'s (1989a) premise that the brain structures necessary for metamemory abilities seem to be different from those that when damaged cause amnesia (i.e., the medial temporal and diencephalic structures). Essentially Janowsky et al. (1989a) assert that the medial temporal and diencephalic structures (which are located within the temporal lobe) do not affect metamemory ability. McGlone and Wands' (1991) findings support Janowsky et al.'s (1989a) assertion because judgement of memory functioning (i.e., metamemory ability) was not affected by whether the temporal lobe was intact (pre-op TL) or not (post-op TL). It should be noted however that had McGlone and Wands (1991) used a more sensitive objective measure (rather than validation of patients' beliefs by family beliefs), they may have found metamemory impairments depending on the component of metamemory that was being assessed. For example patients who have undergone left temporal lobectomies show marked impairment in learning verbal material, in particular paired associates (Beaumont, 1983). Thus, if McGlone and Wands (1991) had given their patient population an actual memory task (e.g., paired-associate learning) and had asked them about their perceptions about their memory ability in relation to their performance on this specific task, they may have found evidence of a metamemory impairment.

There has been no clinical study to date (to the author's knowledge) that has investigated metamemory and memory in a closed-head injured population using experimental procedures. Studies in metamemory and memory have predominantly investigated focal lesions in brain-impaired populations. The present closed-head injured group provides an opportunity to examine a diffuse brain-damaged population. Heilbronner (1992) reviewed Prigatano and Schacter's (1991) fourteen-chapter volume dealing with awareness of deficits after brain injury. He considered the volume to contain "virtually all of the information on unawareness and denial for clinicians and researchers who are interested in studying this phenomenon" (p. 464). Yet, Schacter (1991, cited in Prigatano & Schacter, 1991) could only provide three studies that had investigated metamemory (and only in amnesic patients) in his review of relevant experimental investigations regarding "unawareness of deficit and unawareness of knowledge in patients with memory disorders" (p. 127). Furthermore, Heilbronner (1992) adds that he does not "expect there to be another comprehensive article or book on this topic to appear in the near future, nor should there be" (p. 464). Heilbronner's (1992) commentary can be interpreted in two ways: (1) he is unaware of the importance of potential contributions from cognitive psychology tc the study of awareness of memory deficits; or (2) he may be regarding "awareness of memory deficits" as simply the individual's conscious awareness of their memory deficit without inclusion of awareness for the type of memory deficit or at what particular stage/s (i.e., encoding, retrieval) that the memory deficit/s may or may not be differentially impaired. An examination of both the volume (Prigatano & Schacter, 1991) and Heilbronner's (1992) review suggests the need for further investigation of the metamemory phenomenon in clinical populations. The present study is such an investigation with specific emphasis on the closed-head injured population.

Head Injury

Incidence

Head injuries in the civilian population result from many diverse sources: road and traffic accidents account for approximately 50%; domestic accidents account for about 20%; industrial injuries account for approximately 10%; cases of assault account for approximately 10%; and sport related injuries account for approximately 5%; the remaining 5-10% are caused by other factors (Reitan & Wolfson, 1986). Kraus (1980) reported that hospital admissions for head injuries were four times more frequent for males than females.

Harrison and Dijkers (1992) have estimated that approximately 500,000 new cases of traumatic brain injuries occur each year in the United States. Of these approximately 30% to 50% are either moderate, severe or fatal injuries (Frankowski, Annegers, & Whittman, 1985, cited in Harrison & Dijkers, 1992).

Statistics Canada (1990) reports (based on Workers Compensation cases) that the number of work-related head injuries has escalated at a steady rate since 1986. In 1985, 42,063 work-related head injuries were reported; in 1986, 43,035 were reported; in 1987, 44,060 were reported; in 1988 46,296 were reported and in 1989 47,961 were reported. These are only the figures for work-related head injuries, and do not include other head injury accidents sustained outside the work place, for example highway/road vehicle accidents in Canada. Given the prevalence of head injuries, classification schemes based on the type of head injuries have been developed.

Types of Head Injuries

Head injuries can be classified into two types: closed-head injuries and open-head injuries. Reitan and Wolfsan (1986) refer to closed-head injuries as those in which the blow to the head has not caused a direct pathway from the outer part of the head (scalp) through the skull and soft tissue to the brain; linear skull fractures may or may not be present in a closed-head injury. An open (or penetrating) head injury is characterized by an external object penetrating through the scalp and skull directly into the brain (Reitan & Wolfsan, 1986).

Closed-head injuries may be of the acceleration or deceleration type, and frequently involve rotational forces, resulting in extensive diffuse damage or focal lesions. Acceleration injuries occur when the head is struck by a rapidly moving object while being relatively motionless in comparison to the object that strikes it (Reitan & Wolfsan, 1986). For example, an acceleration injury would occur if an individual is standing or walking on/across a street and is hit by a moving vehicle. Deceleration injuries occur when the head is moving rapidly and strikes a fixed or solid object (Reitan & Wolfsan, 1986). For example, a deceleration injury would occur if an individual stumbles/falls and strikes her/his head on a pavement.

Impact and Impairment caused by Head Injury

Head injury in which there is either focal (i.e., injuries in which there is a lesion large enough to be visualized (using PET, MRI), multifocal, and/or diffuse brain damage (i.e., damage which results from the shaking effect of the impact on the head, and usually associated with widespread disruption of neurological functions, and not usually with macroscopic lesions) typically result in impairment of both physical and mental functions (Khan, 1986). Physical impairment may occur in motor and sensory functions and may include tremors, dyskinesia[2], ataxia[3], hemiparesis[4], and visual and hearing deficits. In most cases physical deficits are accompanied by cognitive deficits, but cognitive deficits can occur without measurable physical impairment (Khan, 1986).

Damage to the brain may also occur from secondary complications occurring after the injury (as opposed to the direct impact of the trauma [primary injury]). These complications may include both intracranial and systemic changes, for example swelling of the brain, intracranial hypertension, infection and shock (Khan, 1986).

Although the nature and degree of cognitive impairment following head injury varies, the most consistent and commonly reported problem is the disturbance of memory (Levin, Benton, & Grossman, 1982; Van Zomeren, 1981). Oddy, Coughlan, Tyerman, and Jenkins (1985) reported that memory

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[2] Dyskinesia - Disturbance of muscular movement (Kolb & Whishaw, 1990) or an impairment of voluntary movement resulting in fragmented or jerky motion (Webster's 9th New Collegiate Dictionary, 1991).

[3] Ataxia - Failure of muscular coordination; any of various irregularities of muscular action (Kolb & Whishaw, 1990).

[4] Hemiparesis - Muscular weakness affecting one side of the body (Kolb & Whishaw, 1990).

deficit was the most persistent and common problem mentioned by both patients and their relatives 7-years post-injury. Additionally Brooks, McKinlay, Simington, Beattie, and Campsie (1987) reported that 7-years after severe head injury, verbal memory deficit was one of the two neurobehavioural sequelae (the other was slowed information processing rate) that was most strongly related to unemployment.

Classification of the Severity of Brain Damage

The duration and degree of coma in an unconscious patient reflects the severity of brain damage. After recovery from coma, the best predictor of the severity of brain damage is the duration of posttraumatic amnesia (PTA). Posttraumatic amnesia is defined as the time interval between the injury and the recovery of continuous memory (i.e., day to day memory), including the period of coma and disorientation (Khan, 1986). Posttraumatic amnesia has been correlated with severity of brain injury, sometimes with the emergence from posttraumatic amnesia being marked by psychological disturbance and/or psychotic episodes (Jones, 1979).

A number of categories have been proposed for the classification of severity of brain injury based on duration of posttraumatic amnesia (Fortuny, Briggs, Newcombe, Ratcliff, & Thomas, 1980; Russell & Smith, 1961; Senelick, 1992).

Russell and Smith (1961) correlated the duration of posttraumatic amnesia (PTA) and the severity of the brain injury in the following way:

PTA < 1 hr = mild injury
PTA 1 - 24 hr = moderate injury
PTA 1 - 7 days = severe injury
PTA > 7 days = very severe injury

Fortuny et al. (1980) elaborated on Russell and Smith's classification of mild head injury to include a "very mild head injury" category because of patients who experienced posttraumatic amnesia for ten minutes or less:

PTA up to 10 min = very mild injury
PTA of 10-60 min = mild injury

Fortuny et al. (1980) arrived at their classification scheme based upon data on age, sex, type of accident, length of stay in hospital, tests of orientation in time and space, and tests of recall and recognition to determine the end of PTA. The distinction between PTA of less than 10 minutes and less than an hour was based on clinical examination involving principally tests of orientation. These classifications were in good agreement with the estimates of PTA made by experienced neurosurgeons.

Senelick's (1992) classification of brain injury is also similar to Russell and Smith's (1961), however he omits the category "very severe injury" on the basis that one category (i.e., "severe head injury") was sufficient to cover posttraumatic amnesia that lasted over 24 hours. Senelick (1992) classifies patients with posttraumatic amnesia of less than one hour as having a mild head injury, patients with posttraumatic amnesia of one to twenty-four hours were considered to have a moderate head injury, and those with posttraumatic amnesia lasting over 24 hours were considered as having a severe head injury. No data supporting this classification system were reported.

A number of others have used a different classification scheme for severity of head injury (e.g., London, 1967; Price & Murray, 1972). London (1967) used the period of time a patient was hospitalized to determine the severity of the head injury. A mild head injury was classified as one in which a patient stayed in the hospital for less than 24 hours, a moderate head injury was classified as one in which a patient stayed for 1 to 7 days, and a severe head injury was classified as one in which a patient stayed in the hospital for more than a week. One potential problem with this criterion is the possibility that a patient's stay in hospital may not be directly related to the head injury, that is, the length of their stay may have also been influenced by other medical complications. Furthermore they may or may not have been experiencing posttraumatic amnesia during the entire time they were in the hospital. Thus the patient's length of stay in the hospital may have been as a result of other criteria, other than or not including, posttraumatic amnesia. Price and Murray (1972) used a much broader set of criteria to determine the severity of head injury: the period of consciousness, the posttraumatic amnesia disorientation, the time between head injury and normal work, and the duration of stay in the hospital. Posttraumatic amnesia disorientation was defined as the period from the time of the accident to the recovery of full continuous memory without confusion (Price & Murray, 1972).

The Glasgow Coma Scale ([GCS] Teasdale & Jennett, 1974) assesses level of consciousness, motor response, verbal response, and the ability of the patient to open her/his eyes. The GCS is used at the time the patient is first examined (both in emergency room situations, and the initial examination in the hospital ward). Patients scoring 8 or less on the GCS are regarded as having severe head injury (Jones, 1979; Khan, 1986). Scores for each measure that is, motor, verbal, and eye opening responses are based on a 4, 6 and 5 point scale, respectively. The GCS classification scheme has been used independently by doctors and nurses on the same patient population, and the scores were found to be consistent. The GCS has been acknowledged as a good predictor of survival and gross functional outcome

(Senelick, 1992), however it is not a reliable predictor of eventual independence and therefore a need developed for other scales such as the Glasgow Outcome Scale (Jennett & Bond, 1975). The GCS and the GOS were designed for different purposes, but with the ability to compliment one another. The GCS was designed to measure the initial depth and duration of coma and impaired consciousness (Teasdale & Jennett, 1974), whereas the GOS was designed to measure the outcome after brain injury using an objective 5-point scale.

Head Injury and Memory

There are three types of memory problems typically produced by head injuries: posttraumatic amnesia (PTA), retrograde amnesia, and anterograde amnesia (Baddeley, Harris, Sunderland, Watts, & Wilson, 1987).

Khan (1986) defines PTA as the time interval between the injury and the recovery of continuous memory. This includes the period of coma and disorientation which gradually merge into one another. The emergence from coma occurs when the individual is able to obey spoken commands, and there is a return of speech (or an equivalent sign from the individual). The end of the disorientation period can occur gradually or suddenly, and is marked by continuous memory for day-to-day events.

Retrograde amnesia (RA) refers to the inability to recall events that occurred prior to the head injury. There are two types of RA: (1) temporary amnesia - which occurs immediately after the trauma, but gradually diminishes, sometimes enabling the individual to remember everything except those occurring a few seconds preceding the accident; (2) a more permanent amnesia that may last for many years (Baddeley et al., 1987).

Anterograde amnesia (AA) refers to the problem that head-injured patients have with new learning (Baddeley et al., 1987) or "ongoing events" (Levin, 1989). Basically, they are unable to remember newly learned information.

In addition to the above three memory problems typically produced by head injuries, other specific memory impairments have been observed over longer periods using methods from experimental psychology. Studies have indicated differences in recall of concrete and abstract words (Richardson, 1979a; Richardson & Snap, 1984), recognition memory performance (Brooks, 1974a), and short-term and long-term recall (Brooks, 1974b). Additionally, semantic memory in head-injured individuals has also been investigated (Goldstein, Levin, Boake, & Lohrey, 1990; Levin & Goldstein, 1986).

Richardson (1979a) compared the recall of concrete and abstract words by 40 male individuals with minor closed-head injury[5] to a control group of 40 male orthopaedic patients. Ten lists (5 concrete and 5 abstract), each consisting of 10 words, were presented at a rate of 3 seconds per word. Following each list presentation, there was an immediate free recall test. After completion of the tenth list, there was an unexpected final free recall of all the words that had been presented.

There were no differences between the groups' recall performance for abstract material for either initial testing or final testing. The control group demonstrated the normal superiority for recall of concrete words over abstract words (Paivio, 1971; 1986; Richardson, 1974; 1980), but the head-injured group did not. The control group recalled significantly more concrete words on both the immediate and delayed tests compared to the CHI group. Richardson attributed his findings to the use of mental imagery as a more effective memory strategy for concrete material used by the control group. He concluded that closed-head injuries gave rise to a specific impairment in the use of mental imagery as a form of encoding. Richardson (1979a) also analyzed his data in terms of locus of cerebral lesion (left, right and midline impact), but found no significant difference in recall performance based on location of lesion.

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[5] Minor closed head injury was defined as a period not exceeding seven hours from the trauma to return of continuous memory (Richardson, 1979a).

Richardson and Snap (1984) replicated Richardson's (1979a) study with the following changes: (1) a severe closed-head injury group, an in-patient orthopaedic (IPO), and an out-patient orthopaedic (OPO) group were used; (2) they forewarned participants of the final recall test. They found that the IPO group recalled significantly fewer concrete and abstract words than did the OPO group on the immediate tests. The severe head-injured patients revealed impairment on both immediate and delayed recall of concrete words but not abstract words, when compared to the IPO group. The control group revealed an advantage in memory performance for concrete over abstract words, but there was no significant difference in the recall of concrete versus abstract words for the head-injured group. These results are consistent with Richardson's (1979a) findings in which the head-injured group did significantly poorer than the control group on recall of concrete words.

Brooks (1974a) also investigated memory performance in patients with closed-head injuries (diffuse). The patients were tested using a continuous recognition memory procedure (Kimura, 1963) involving the identification of eight recurring shapes among a series of 160. Results indicated that the closed-head injured patients had fewer correct recognition responses than the control group (orthopaedic outpatients undergoing rehabilitation after injuries to their lower limbs). The head-injured group produced more false negative errors (i.e., a failure to identify a previously presented item as familiar) than the control group, but the groups did not differ in the number of false positive errors (i.e., incorrectly identifying a "new" shape as a recurrence). Brooks suggested that the head-injured group's poor performance was due to either less initial learning or a strategy of increased caution or both. Brooks could not distinguish between these alternatives based on his data. Brooks (1974a) explains the strategy of caution as one whereby the patient adopts a very strict decision criterion and identified an item only if she/he was quite certain. This explanation requires a low level of false positives as the patient would be unwilling to make guesses. Patients did demonstrate a low level of false positives; furthermore there was no significant difference between the groups' false positive performance. Finally, Brooks (1974a) found that the severity of the memory deficit was related to length of PTA, but not to the interval between injury and testing, nor to the presence of neurologic signs (e.g., dysphasia) during testing.

In a second study, Brooks (1974b) analyzed participants' performance within the framework of signal detection theory[6]. He found that head-injured patients produced a significantly lower *d'* (an index of recognition

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[6] See Richardson (1979b) for a review of signal detection theory and in particular Brooks' (1974b) application of it.

sensitivity or discriminability), and a significantly higher *B* (an index of response bias). Brooks (1974b) concluded that severe head injury produced poorer memory efficiency and a more cautious response criterion.

Subsequently, Brooks (1975) investigated short-term memory (STM) and long-term memory (LTM) processes in patients with severe (diffuse) brain damage due to head injury. His control group consisted of limb-injured patients. A free recall test of 20 lists of 10 high frequency words (Thorndike & Lorge, 1944) and a Digit Span Test were used. Brooks (1975) found no significant differences in performance on the Digit Span Test. However, head-injured patients performed significantly poorer on delayed recall than the control group. Brooks (1975) suggested that this may be due to a long-term memory deficit in either or both stages of encoding and retrieval. There was no short-term memory deficit in the head-injured patients.

Levin and Goldstein (1986) and Goldstein et al. (1990) investigated whether there was any relative benefit in memory for words that were processed semantically versus words that were processed physically or acoustically. Levin and Goldstein (1986) investigated memory for three types of word lists each presented during four trials: unrelated, related but unclustered, and clustered (i.e., blocked). They postulated that, if, as a result of closed-head injuries, there was a disruption in the ability of patients to process words semantically, then the CHI individuals would be unable to benefit from even the most structured of the three word lists (i.e., clustered). However, if the memory impairment in closed-head injuries was primarily a deficiency of applying elaborative strategies, then CHI individuals should show a facilitation in learning the clustered word list relative to the other two word lists (i.e., the unrelated and related but unclustered lists). Each of the three lists consisted of 18 words. The unrelated word list consisted of 18 nouns from different conceptual categories (Battig & Montague, 1969). The related-unclustered and clustered word lists also consisted of 18 nouns, six from each of three conceptual categories (house parts, fruits, four-legged animals). While the CHI group recalled fewer words overall than the control group, the beneficial effects of blocking related items at study was equivalent for the two groups. The results from Levin and Goldstein's (1986) investigation provide evidence for the CHI group's partially preserved ability to process material semantically. The control group demonstrated overall greater memory performance; recall for both groups on the clustered list was better than for the unrelated and related-unclustered lists. Since CHI individuals were able to show facilitation of verbal memory from the organization inherent in a list at input, it appears that it may be a quantitative rather than a qualitative change in memory performance that characterizes their deficit.

Goldstein et al. (1990) examined whether induced semantic encoding (whether a word was a member of a category of objects or functions) compared to physical (the detection of a letter) and acoustic (the detection of a rhyme relationship) forms of processing would enhance memory performance in CHI patients as it does in normal controls. There were 60 target words, with 20 words encoded in each of the physical, acoustic and semantic conditions. For each encoding condition a question could be correctly answered "yes" or "no". Using the levels of processing paradigm (Craik & Lockhart, 1972), they hypothesized that, if CHI patients can employ elaborative strategies involving attention to semantic features, then their recognition memory should be greater for semantically processed words compared with that for physically or acoustically processed words.

Results indicated that the control group recognized significantly more words than the closed-head injured patients. Both groups had better performance in the semantic condition compared with the physical and acoustic conditions; however the advantage for semantic processing was greater for the control group. Goldstein et al. (1990) concluded that, based on these findings as well as those of Levin and Goldstein (1986), closed-head injuries result in "a relative sparing of the ability to access and recognize semantic relations and to utilize such relationships to guide learning and recall" (p. 295).

In summary the studies discussed above have documented persistent and general impairment of recall performance (Brooks, 1975; Richardson, 1979a; Richardson & Snap, 1984) and recognition memory (Brooks 1974a; 1974b) after moderate and severe closed-head injury. Studies have also demonstrated that CHI patients benefit from semantic processing but not to the same extent as normals (Goldstein et al., 1990; Levin & Goldstein, 1986). Finally, Richardson (1979a, Richardson & Snap, 1984) has demonstrated that CHI patients do not show the advantage in recall of concrete words over abstract words that is characteristic of normals.

Forgetting Rates for Item and Associative Information

Murdock (1974) distinguished three types of information represented in human memory: item, associative and serial information. Item information represents the occurrence of individual items or events; associative information represents connections between events (Hockley, 1991, 1992; Humphreys, 1976, 1978). Serial information refers to memory for sequences of events (e.g., letters of the alphabet or days of the week) (Murdock, 1974). As this study is only concerned with item and associative information, further discussion will be restricted to these categories of information.

Item recognition requires discriminating old or studied words from new or nonstudied words. Associative recognition involves the discrimination of random word pairs that had been studied together from word pairs that had not been presented together (Hockley, 1992).

Murdock and Hockley (1989) examined forgetting rates for associative information, and Hockley (1991, 1992) compared forgetting rates for item and associative information. Murdock and Hockley (1989) examined the forgetting rate for associative information as a function of test lag (the number of events that intervene between study and test presentation) in a continuous recognition paradigm. They found no forgetting of associative information over test lags varying from 1 to 26 in four experiments.

Hockley (1991) compared item and associative recognition performance as a function of study-test lag in four experiments. Results indicated that the forgetting rate for associative information was less than the forgetting rate for item information. This was apparent in both the continuous recognition procedure (Experiments 1, 2, & 3) and the study-test paradigm (Experiment 4). Furthermore, memory for item information decreased with increasing test lag (Experiments 1-3) and over study-test interval in the study-test procedure (Experiment 4). The difference in forgetting rates was also found to be independent of the participants' confidence in the accuracy of their recognition decision (Experiment 3).

Subsequently, Hockley (1992, Experiment 4) investigated immediate and delayed recognition memory for item and associative information using a forced-choice study-test procedure. There were 10 study-test trials followed by one final recognition test (delayed recognition memory). He reported that the overall accuracy did not differ between item and associative recognition on the immediate memory test. On the final recognition test (delayed memory), both item and associative performance declined; a significantly greater decline was observed for item recognition. These results further support the conclusion that the forgetting rate for associative information is less than the forgetting rate for item recognition.

There has not been any study to date in the published literature (of which the author is aware) that has investigated recognition memory for item and associative information in head-injured populations. The present study provided the opportunity to extend research documented in the normal population for specific types of information (i.e., item and associative information) to a head-injured population. Additionally the present study assessed whether head-injured individuals process different types of information (i.e., associative versus item information) differently. As a theoretical concern of experimental cognitive psychology, the present study provided an opportunity to determine the generalizabilty and/or limitations of previous findings to a closed-head injured population.

Experimental Rationale

The theoretical framework for the present study was based on the research reported by Hockley (1991, 1992; Murdock & Hockley, 1989) and previous research conducted by the author.

Previous Research

Three experiments were undertaken by the author prior to the present study. Participants for all three experiments were obtained from Wilfrid Laurier University's Psychology Participant Pool.

Experiment 1 was designed to determine whether certain types of feedback would enhance memory performance, use of memory strategies (i.e., rote rehearsal, verbal elaboration, and interactive imagery) and metamemory (memory monitoring). Abstract versus concrete paired associates (PA) were used over two study-test trials, in a cued-recall paradigm. Memory monitoring consisted of a prediction and postdiction judgement, based on a 5-point confidence rating of recallability, and confidence rating of response, respectively.

Experiment 1 consisted of three groups: (1) a control group which did not receive any feedback; (2) a Feedback 1 group in which participants received specific information based on their actual performance; and (3) a Feedback 2 group which received specific information based on actual performance (i.e., whether the participant had given a correct or incorrect response) and the effectiveness of the strategy (as determined by correct or incorrect recognition of the item) initially used by the participant (i.e., rote rehearsal, verbal elaboration, or interactive imagery).

Experiment 1 did not support the main hypothesis of a difference in recall between the feedback and no feedback groups. There were however significant differences (when the groups were collapsed) between trials, type of paired-associates (i.e., concrete or abstract), and memory monitoring (predictions and postdictions). From trial 1 to trial 2, recall performance and postdiction ratings improved while prediction ratings declined. Overall, prediction ratings were underestimated compared to actual performance, however concrete words were given higher ratings than abstract words, implying that participants felt more confident about their ability to recall concrete words than abstract words. Similarly, postdiction ratings were higher for concrete words than abstract words, however postdiction ratings overall were more accurate than prediction ratings.

The following reasons may explain the findings of Experiment 1: (1) two trials may not have been sufficient to reveal an effect due to feedback; (2) the abstract words may have been too difficult; and (3) based on the overall low prediction ratings made by participants, it appears that the task demand (cued-recall) may have been too difficult.

Experiment 2 was designed to correct some of the problems encountered in Experiment 1. A less rigid criterion of concrete/abstract was used to form paired-associates (i.e., the imagery and concrete ratings ranges were expanded, thus avoiding the restrictiveness of the previous ranges), five study-test trials were included (instead of two), one final test of delayed memory was added, and a forced-choice recognition procedure (instead of cued-recall) was adopted to assess memory for associative information. Only the accurate feedback condition was used since the feedback manipulation had no effect on performance in Experiment 1. The results of Experiment 2 revealed that noun paired-associates received higher prediction and postdiction ratings, and were correctly recognized more than non-noun paired-associates. This was independent of the feedback manipulation and test delay. Overall there were higher ratings (more accurate) for postdictions than predictions. The results obtained from the final test (delayed memory) were also considered in terms of forgetting rates. Consistent with Hockley's (1992) findings for associative information, pairs from each study list were remembered at approximately similar levels on the final test. Additionally, there were higher levels of recognition for noun paired-associate items across study lists (1-5) on the final test, consistent with Murdock and Hockley's (1989) findings.

Experiment 3 was an attempt to (1) replicate the findings of Experiment 2 for associative information, and (2) extend Experiment 2 by comparing recognition memory for item and associative information with feedback versus no feedback, as well as ratings of predictions and postdictions. There were four study-test trials and one final recognition test.

The results from Experiment 3 indicated a significant difference between the feedback and no-feedback groups, but only on the metamemory variables (i.e., prediction ratings and postdiction ratings). The feedback group gave higher (more accurate) prediction ratings and postdiction ratings on both the immediate and final recognition tests than the no-feedback group. There were also significant differences for immediate and final postdictions and proportion of correct recognition responses for associative information; these differences were dependent upon whether the paired-associate were nouns or non-nouns. Predictions, final postdictions, and immediate and final recognition responses for item information did not reveal any significant d fference based on whether the PA were nouns or non-nouns. Essentially, feedback seems to influence metamemory but not recognition memory performance. Overall recognition memory for associative information was better than recognition memory for item information, especially on the final (i.e., delayed) recognition test.

Based on these studies, a number of hypotheses were generated. A brief overview of the aims of the present study and specific hypotheses will follow. The general aim of the present study was to apply an area of theoretical interest (memory for item and associative information) to determine: (1) the level of accuracy of a closed-head injured (CHI) population's metamemory abilities (in particular their memory monitoring abilities); (2) how closed-head injured patients process different types of information (i.e., item and associative); and (3) advance our understanding of the memory function in a closed-head injured population.

Specific aims included determining: (1) whether there were specific differential memory impairments involved in the retrieval of item versus associative information in a CHI population; (2) whether CHIs can effectively monitor their encoding and retrieval of information as determined by the relationship between their prediction ratings and postdiction ratings; and (3) the relationship between memory monitoring and recognition memory performance for item and associative information in CHI individuals.

In the present study, recognition memory was investigated for item and associative information consisting of abstract and concrete words during three study-test trials and one final recognition test. A comparison of concrete and abstract words was included in order to replicate the lack of an advantage in memory for concrete words in CHI patients reported by Richardson (1979a; 1980) and Richardson and Snap (1984), and to determine whether these effects extend to associative recognition. Following each presentation of study words, participants were asked to give a prediction rating (i.e., a confidence rating based on future performance). After each response on the recognition test, participants were asked to give a postdiction rating (i.e., a confidence rating based on past performance). Several hypotheses were generated in relation to the present study.

Hypotheses

The two forms of memory monitoring, predictions and postdictions, differ in that one is based on the given responses (postdictions) versus potential responses (predictions). They both however attempt to determine the individual's level of awareness of their memory functioning. Predictions were used to determine level of awareness at the time of encoding and postdictions were used to determine level of awareness at the time of retrieval.

Metamemory related hypotheses:

(1) CHI's will provide higher prediction ratings than the normal control group.

Although there have been no investigations of metamemory in the CHI population (at least not to the author's knowledge), related research that has investigated components of metamemory (e.g., feeling-of-knowing) in other brain-impaired populations (frontal lobe lesions, temporal lobe seizure patients) has suggested a pattern of deficits. For example, Janowsky et al. (1989a) found that frontal lobe lesion patients tended to overestimate their subsequent memory performance, as revealed by their feeling-of-knowing judgements. Similar findings were obtained by Shimamura and Squire (1986) for patients with Korsakoff's syndrome who were unable to make accurate feeling-of-knowing judgements when asked to predict their performance on a subsequent recognition memory test. Additionally, Prevey et al. (1988)

found that both left and right temporal lobe seizure patients overestimated their memory abilities in comparison to normal controls.

(2) Postdiction ratings made by the CHI and control groups are expected to be more positively related to memory performance than their prediction ratings for both item and associative information.

Unlike the popular feeling-of-knowing phenomenon, the postdiction rating is based on the participant's judgement of the accuracy or correctness of her or his recognition response. Shimamura and Squire (1988) examined amnesic patients' and control participants' confidence ratings on cued-recall and recognition memory tests to determine whether patients have as much awareness as normal controls about the accuracy of their responses. Results indicated that the amnesic and control groups reported similar confidence ratings for correctly recalled items and that both groups were able to discriminate between correct and incorrect answers. Shimamura and Squire (1988) suggested that confidence judgements that follow memory responses may be easier than predictions about performance that precede memory responses. This may be because prediction ratings may require more inferential ability and more elaborative retrieval strategies than do postdiction confidence ratings, and these abilities may be impaired in populations that have suffered cortical damage including frontal lobe damage (Shimamura, Jernigan, & Squire, in press, cited in Shimamura & Squire, 1988).

(3) Postdiction ratings for item and associative information are not expected to differ between the groups.

Hockley (1991, Experiment 3) found that the degree of confidence participants had in their responses was independent of whether they were for item or associative information. The degree of confidence participants had in their responses can be interpreted as a postdiction measure. This would lend support to the hypothesis that there should be no difference between postdictions made for item and associative information by the control group.

Item versus Associative Information for Concrete and Abstract Paired-Associates:

(1) The CHI group's performance will not reveal as great an advantage as that of the control group for recognition of concrete words compared to abstract words for associative and item information (CHI's did not demonstrate an

advantage in recall of concrete words over abstract words [Richardson, 1979a; Richardson & Snap, 1984]). Thus, a group by wordtype interaction is expected.

Forgetting rates (Immediate versus Delayed Memory):

(1) Forgetting rates (in terms of immediate versus delayed memory performance) for the control group are expected to be greater for item information compared to associative information (Hockley, 1991; 1992). A similar pattern of forgetting for both types of information is expected for the CHI group except the extent of forgetting will be more pronounced. Forgetting rates may also be influenced by memory for concrete versus abstract words. For the closed-head injured group, forgetting rates may be similar for concrete and abstract material, whereas for normal controls forgetting rates are expected to be greater for abstract items compared to concrete items (Richardson, 1979a; Richardson & Snap, 1984).

If Richardson's (1979a) and Richardson and Snap's (1984) findings are replicated, then the CHI group's forgetting rate for concrete material versus abstract material should not differ because there was initially no significant advantage in recall of concrete words.

(2) Overall delayed memory performance is expected to be poorer for the closed-head injury group than for the control group. This hypothesis gains support from Brooks' (1975) findings that closed-head injured individuals demonstrate an impairment in their long-term memory.

Method

Participants

Nineteen (19) closed-head injured (CHI) patients (all with diffuse brain damage) were recruited from the Nova Scotia Rehabilitation Centre, Halifax, Nova Scotia. Four CHI patients were not included in the study; three patients were unable to complete the study due to their physical limitations and/or emotional instability, and the fourth patient was excluded due to his age (69 years) and low level of education. Of the fifteen CHI patients included in the study, eight were females and seven were males. The CHI group's average age was 34.6 years (range 19-61) and their average years of education was 11.9.

All CHI patients had mild to moderate head injuries. Inclusion criteria for the head-injured group were based on whether the individuals had sustained a closed-head injury (determined by hospital medical records), and the severity of the injury (determined by the length of posttraumatic amnesia and neuropsychological assessment by a neuropsychologist, CMK). Exclusion criteria included screening (by CMK) to ensure that the closed-head injured patients did not have a history of psychiatric illness, alcohol or substance abuse, or neurological impairments.

There were two control groups consisting of a total of thirty (30) normal (non-CHI) individuals (university students and volunteers from the community). Fifteen were matched for age, level of education and gender to the CHI group (the matched control group). The average age for the matched control group was 33.7 years (range 22-58); the average years of education was 11.5. The matched control group consisted of nine females and six males. T-tests indicated that the matched control group and the CHI group did not differ in terms of age, education level and gender. The remaining unmatched 15 participants were used as a second control group (i.e., the unmatched control group); this group had a mean age of 23.4, a mean education level of 13.3, and consisted of nine females and six males.

A screening questionnaire was used for the control participants (Appendix A) to ensure that they did not have a previous head injury, serious medical illness, neurological impairment, and alcohol or substance abuse.

Signed consent forms were obtained prior to beginning the study (Appendix B).

Materials

Words (concrete and abstract) were taken from the word list of Gilhooly and Logie (1980). A total of 102 concrete words were selected to form 51 concrete pairs (see Appendix C) and 102 abstract words were selected to form 51 abstract word pairs (see Appendix D). Concrete word pairs and abstract word pairs were randomly paired except for the constraint that words that formed study pairs were matched for length of word (+/- 1 letter). Mean concreteness ratings for concrete words ranged from 5.5 - 7.0 (mean rating = 6.31); mean concreteness ratings for abstract words ranged from 3.5 - 5.0 (mean rating = 3.98). Mean imagery ratings for concrete words and abstract words were 5.87 and 4.44, respectively.

Each study-list word-pair was printed on an individual sheet (21.3 by 27.6 cm). Each of the three immediate memory tests consisted of the presentation of twelve sheets with either two items or two pairs printed centred, top and bottom, on each sheet. For the final recognition test (delayed memory), there were thirty-six pairs each printed on an individual sheet.

Prediction and Postdiction Scales were printed on single sheets (21.3 by 27.6 cm), with one sheet (prediction scale) following each study pair presentation (Appendix E) and one sheet (postdiction scale) following each test item/pair presentation (Appendix F).

Nine neuropsychological tests were used to assess cognitive functioning:

(1) The *National Adult Reading Test* (NART; Nelson, 1982). It has been suggested that since vocabulary correlates best with overall intellectual ability level and tends to resist the dementing process better than any other intellectual attainment, tests such as the NART may be the best indicator of premorbid ability (Lezak, 1983). The NART was used to provide a means of estimating the premorbid intelligence of adult patients suspected of suffering from intellectual deterioration (Nelson, 1982).

(2) The *Wechsler Adult Intelligence Scale-Revised* (WAIS-R; Wechsler, 1981) consists of a series of intelligence tests in a battery form, administered individually. There are eleven subtests: six are verbal measures and primarily assess an intellectual, memory factor; five are performance measures and assess visual-spatial abilities (Groth-Marnat, 1984). Three of the six verbal measures of the WAIS-R were used: Digit Span, Vocabulary, and Similarities. Four of the five performance measures were used: Picture Completion,

Picture Arrangement, Block Design, and Digit Symbol (Wechsler, 1981).

(3) The *Wechsler Memory Scale-Revised* (WMS-R; Wechsler, 1987), consists of eight subtests measuring short-term learning and recall of both verbal and figural material which are read (verbal) and presented visually (figural) to the participant. Only one verbal measure was used: Logical Memory I (immediate recall) and II (delayed recall) (Wechsler, 1987).

(4) The *Rey-Osterrieth Complex Figure Test* (Osterrieth, 1944, cited in Berg, Franzen, & Wedding, 1987) was also administered. It was designed by Rey (1941, cited in Berg et al., 1987) to investigate both perceptual organization and visual memory in brain-damaged individuals, and was later standardized by Osterrieth (1944, cited in Berg et al., 1987). The patient is presented with the Rey figure and asked to copy the figure while it is present. The patient is timed and the drawing later marked according to the Rey-Osterrieth Complex Figure's 36-point scoring system. After a delay period (approximately 45 minutes), the individual is asked to draw as much of the figure as she/he can remember.

(5) The *Modified Card Sorting Test* (Nelson, 1976) is based on the Wisconsin Card Sorting Test which was devised to study "abstract behaviour" and ability to "shift set" (Berg, 1948; Grant & Berg, 1948). The patient is presented with a

set of cards which she or he sorts according to a principle that the patient must deduce from the examiner's response patterns.

(6) *The Quick Cognitive Screening Test* (Majors, 1992) was used as an initial screening device to briefly assess the CHI patients' current cognitive status.

(7) The *Verbal Fluency - Controlled Word Association Test* (Borowski, Benton, & Spreen, 1967) was used to measure speed and fluency in verbal production. This test consists of three word naming trials using the letters F, A, and S, respectively (Berg et al., 1987). The participant is asked to name as many words as they can beginning with the letters F, A, and S, and is given one minute for each letter. A large number of patients following brain damage experience changes in speed and fluency of verbal production (Berg et al., 1987).

(8) The *Boston Diagnostic Aphasia Test* (Goodglass & Kaplan, 1972) is a test battery consisting of a number of subtests designed to systematically explore the language capabilities of the individual. Subtests include tests of auditory and visual comprehension, oral and written expression (including tests of repetition, reading, naming and fluency) and conversational speech (Kolb & Whishaw, 1990). Only the naming subtest (oral expression) was used in the present study to determine whether there was any language impairment that would influence memory performance.

(9) Finally, the *Unconventional Views Test* (Warrington & Taylor, 1973) was used. It consists of photographs of common objects (e.g., guitar, bucket, step ladder) taken from an unusual viewpoint. The individual is first presented with the unusual view of the object and asked to identify it, then later is presented with the usual/ conventional view of the object and asked to identify it. In essence the task requires that "a set of cues not normally experienced for an object be integrated and turned into a representation from which meaning can be extracted" (Beaumont, 1983, p. 92).

Procedure

Before taking part in the study, participants were asked to sign a consent form (Appendix B). Demographic information was obtained from the participant, followed by the administration of the Quick Cognitive Screening Test (Majors, 1992). Prior to the beginning of the experimental recognition memory test, participants were informed about the nature of the task - they were told that they would be presented with word pairs; they were to study one pair at a time after which they would be given a forced-choice recognition memory test comprised of either an item or items (word pairs) that they had studied. Each participant was given a practice trial consisting of the presentation of four word pairs. After each word pair, they were asked to give a verbal prediction rating. The participants were then given a forced-choice recognition memory test for item and associative information based on the previously presented four word pairs. After each forced-choice response, participants were asked to give a postdiction rating.

The test session consisted of four trials. The first three trials were study-test trials. The last trial consisted of a final recognition memory test of words studied during the previous three trials but not tested.

Each of the three study trials consisted of the presentation of thirty-four word-pairs, of which the first two served as primacy buffer pairs, and the last two as recency buffer pairs; the primacy and recency buffers were not tested. Study pairs were presented at a rate of 5 seconds per pair, during which time the participants were required to read the pair out loud. Following each study pair, the participant was asked to give a prediction rating, that is, a confidence rating of future memorability based on a five-point scale (1: 0% 2: 25% 3: 50% 4: 75% 5: 100%). As the study lists only consisted of word-pairs, the prediction confidence ratings were based on two words, with the forewarned knowledge that participants may be tested for either the word-pair or a single word from the pair. The confidence rating therefore was made based on the participant's overall ability to recognize the words if they were presented as a word-pair or as a single item (i.e., if only one word was presented).

After each study list, there was an immediate forced-choice recognition memory test. To construct the immediate test lists, the study list was subdivided into six consecutive blocks of five presentations (excluding primacy and recency buffers); this procedure was based on the one used by Hockley (1991). Each associative recognition test consisted of two pairs: one "rearranged" test pair (derived from words combined from adjacent study pairs) and one "intact" study pair. Each item recognition test consisted of two words: one "old" word from each list block, and one "new" word (that is, not presented in the study list). Thus, the immediate test consisted of six old/new item tests and six intact/rearranged associative tests. Subjects were allowed to proceed through the test list at their own pace.

On the immediate tests and the final recognition test, subjects were asked to indicate their response to the examiner by saying "TOP" to refer to the top pair/item, or "BOTTOM" to indicate the bottom pair/item. Their response was based on the question "which of the words [items]/ word-pairs do you think is the correct one, that is, the one that you had previously studied ?". Following their response, they were asked to indicate, based on a five-point rating scale, how confident they were that their response was the correct one (postdiction rating).

There were twelve tests (six item and six associative tests) from each study list on the final recognition test, for a total of thirty-six final recognition test pairs[7]. The intact pair was the untested pair from each study list block. The rearranged associative test pairs were the complementary items from the rearranged pairs on the immediate test. That is, in constructing the rearranged pairs for the immediate tests, the right word from one pair and the left word from the preceding or following pair were combined. The rearranged pairs for the final recognition test were constructed from the two untested words from the same two pairs. For the item test on the immediate tests, the "old" items were either the right or left member of a pair; on the final recognition test, the "old" item was the untested item from the same pair. All tests were subject paced. The participant was informed of the final recognition test prior to its commencement (i.e., after completion of the third recognition memory test).

Upon completion of the recognition memory test, the neuropsychological battery of tests was administered. Approximately two hours was required for participants to complete the entire session.

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[7] The construction of the final recognition test (i.e., intact and rearranged test pairs, and "old" items) was based on the procedure used by Hockley (1991, 1992).

Results

Neuropsychological Tests Results

Performance on all neuropsychological tests was analyzed using the analysis of variance (ANOVA) procedure; means for the matched control group and CHI group are reported in Table 1.

Significant differences were obtained between the CHI group and the matched control group for their current level of intellectual functioning. Results indicated lower scores for the CHI group compared to the matched control group on all of the WAIS-R scales (i.e., FSIQ, VIQ, PIQ). The Wechsler Adult Intelligence Scale-Revised (WAIS-R) Full Scale IQ (FSIQ) score differed between groups, $\underline{F}(1, 28) = 21.76$, $\underline{p} <.01$, as did the WAIS-R Verbal Scale IQ (VIQ) score, $\underline{F}(1, 28) = 17.85$, $\underline{p} <.01$, and the WAIS-R Performance Scale IQ (PIQ) score, $\underline{F}(1, 28) = 11.28$, $\underline{p} <.01$.

The Quick Cognitive Screening Test Global Score also revealed a reliable deficit for the CHI group relative to the control group, $\underline{F}(1, 26) = 10.23$, $\underline{p} <.01$. This result further supports the overall difference between the groups' current level of cognitive functioning.

Although the need to assess the premorbid level of intellectual function was only required for the CHI population, the control groups were also assessed for purposes of analysis. The National Adult Reading Test (NART) was used to assess premorbid level of intellectual functioning. The National Adult Reading Test (NART) Full Scale IQ score did not differ significantly between groups, $\underline{F}(1, 27) = 4.05$, $\underline{p} = .054$, nor did the NART Verbal Scale IQ score, $\underline{F}(1, 27) = 4.07$, $\underline{p} = .054$. The NART Performance Scale IQ scores did differ significantly between groups, $\underline{F}(1, 27) = 4.24$, $\underline{p} < .05$. The premorbid intellectual level of the CHI group did not differ from the control group for the Full Scale IQ or Verbal Scale IQ, however the PIQ did reach significance. Given these results it appears that the overall premorbid intellectual functioning of the CHI group was not too different from the matched control. Furthermore, there is no a priori reason to expect a difference in premorbid intellectual functioning given that both the matched control group and the CHI group were matched for age, level of education and gender.

The difference scores (DIF) refers to the difference between the NART IQ scores and the WAIS-R IQ scores. These scores were analyzed to determine whether there was a difference between the premorbid level of cognitive function and present level, but more importantly to determine whether the difference was significant between groups.

Table 1

Means and Standard Deviations (SD) for Neuropsychological Tests

Tests	Matched Control		CHI	
	Mean	SD	Mean	SD
QCST-Global Score	98.14	4.88	90.00 **	8.18
Rey-Copy[+]	35.00	2.00	30.75 *	6.89
Rey-Delay	18.50	5.76	9.25 **	5.50
WMS: Logical Mem I	24.73	5.98	18.57 *	8.59
WMS: Logical Mem II	22.20	6.17	10.93 **	9.47
WAIS-R FSIQ	102.40	8.09	88.40 **	8.35
WAIS-R VIQ	103.67	9.59	90.13 **	7.87
WAIS-R PIQ	101.20	7.74	88.33 **	12.26
NART-FSIQ	111.67	5.41	107.43	5.93
NART-VIQ	111.13	6.03	106.50	6.33
NART-PIQ	111.00	4.23	107.63 *	4.56
DIF-FSIQ	9.27	6.82	18.50 **	8.05
DIF-VIQ	7.47	8.10	15.50 **	6.38
DIF-PIQ	9.80	7.22	19.36 *	12.92
Verbal Fluency	13.57	3.91	8.81 **	3.26

* $p<.05$. ** $p<.01$.

[+] It should be noted that in this comparison the difference in variance between the groups violates the assumption of homogeneity of variance, which makes the interpretation of this difference questionable.

Note. DIF = Difference scores between NART and WAIS-R measures.

Results indicated significant differences between the groups' Full Scale IQ (DIF-FSIQ) scores, $F(1, 27) = 11.17$, $p < .01$, Verbal Scale IQ (DIF-VIQ) scores, $F(1, 27) = 8.72$, $p < .01$, and Performance Scale IQ (DIF-PIQ) scores, $F(1, 27) = 6.16$, $p < .05$. These findings indicate that the difference in intellectual functioning was greater for the CHI group compared to the control group.

The impaired cognitive functioning of the CHI group was also apparent on several other tests. Overall these tests demonstrated impairment of both immediate and delayed memory performance, with a more pronounced impairment on the delayed tests.

Scores on both the Rey Osterrieth Complex Figure Copy and Delay tests differed significantly between groups, $F(1, 25) = 5.21$, $p < .05$, and $F(1, 25) = 19.71$, $p < .01$, respectively. The CHI group scored lower than the matched control group for both the Rey Copy and Delay tests. These results imply an impairment of both perceptual organization and visual memory in the CHI group. The Rey delayed test revealed a more pronounced impairment than the copy test.

The Wechsler Memory Scale-Revised Logical Memory I (immediate test) and II (delayed test) significantly differed between groups, $F(1, 25) = 5.03$, $p < .05$, and $F(1, 25) = 13.34$, $p < .01$, respectively. On both the immediate and delayed Logical Memory tests, the matched control group performed better (i.e., had higher scores) than the CHI group. The differences between the groups' performance on the delayed test was much more pronounced than on the immediate test.

Mean verbal fluency for letters revealed a significant difference between groups, $\underline{F}(1, 27) = 12.75$, $\underline{p} < .01$, with the CHI group exhibiting a significantly lower level of performance than the control group. This test is considered to be a sensitive indicator of brain dysfunction (Beaumont, 1983; Lezak, 1983).

The neuropsychological tests results indicate three conclusions: (1) the CHI group was not too different from the matched control group in overall level of intellectual functioning prior to injury; (2) at the time of testing, the two groups were significantly different in their level of intellectual functioning; and (3) the CHI group demonstrated a more pronounced impairment on the delayed component of memory tests compared to the immediate component.

The above tests indicate differences in the intellectual functioning between the CHI and matched control groups. The pattern of deficits reflects a diffuse impairment rather than specific or localized deficits. This could be due, in part, to a generalized slowing down of cognitive functioning in the CHI group.

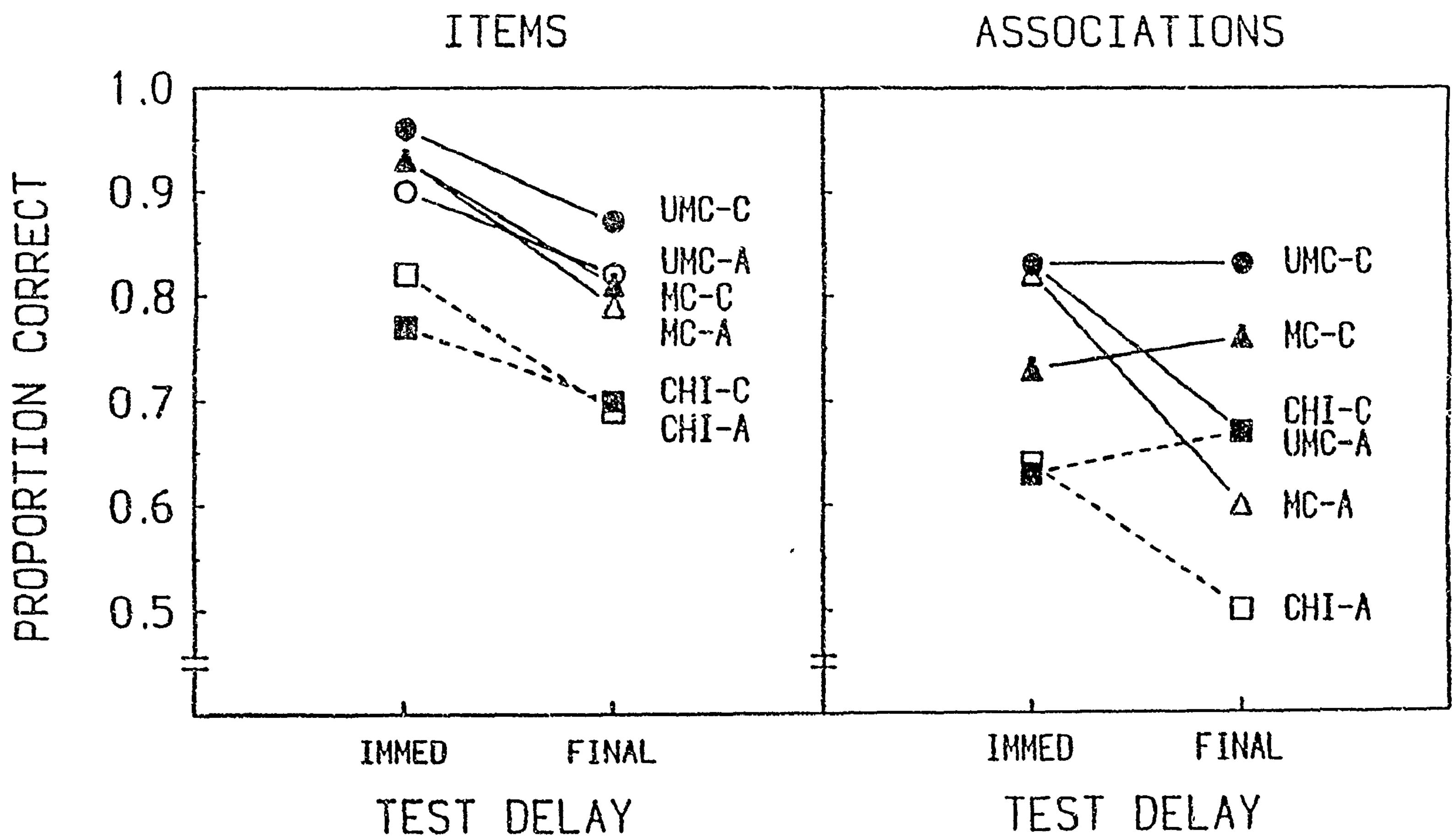
Mean Proportion of Correct Recognition Performance

Recognition memory performance was analyzed for three groups: the CHI group, the matched control, and the unmatched controls. The unmatched control group was used because they were younger, had a higher education level, and seemed more representative of previous populations tested for item and associative memory (e.g., Hockley, 1991; 1992). Thus the unmatched control group in a sense served as a control for the matched control group.

Results obtained for item and associative recognition for concrete and abstract words on immediate and final tests are illustrated in Figure 1. The left panel displays the results obtained for item recognition performance and the right panel displays the results obtained for associative recognition performance for both immediate and final tests. A mixed model analysis of variance was used to analyze recognition performance for the three groups (GROUP), for item and associative information (TESTTYPE) with concrete and abstract words (WORDTYPE) for immediate and final tests (DELAY).

Results indicated a significant main effect for Group, $\underline{F}(2, 42) = 8.34$, $\underline{p} < .01$. Based on the overall significant main effect of Group, a posthoc multiple comparison test was used to evaluate the differences between the groups. Using the Student Newman Keuls procedure, results indicated that

Figure 1. Mean Proportion of Correct Recognition for Item and Associative Information for Concrete (C) and Abstract (A) Words on Immediate and Final Tests for the CHI, Matched Control (MC) and Unmatched Control (UMC) groups.



both the matched and unmatched control groups (means = 82.42 and 85.84, respectively) differed from the CHI group (mean = 69.64) at the p <.05 significance level, however the matched and unmatched control groups did not differ significantly from each other. There were no significant Group interactions, thus all predictions involving Group interactions were not supported.

There was a significant main effect of Testtype, $F(1, 42) = 25.90$, $p < .01$; more item information was recognized compared to associative information. Recognition performance significantly differed for immediate and final tests, $F(1, 42) = 47.30$, $p < .01$; there was greater recognition on the immediate versus the final test. It was predicted that there would be more forgetting by the CHI group than the control group for item information versus associative information, thus a Group x Testtype x Delay interaction was predicted. Results failed to support this prediction. There was however a significant two-way interaction of Wordtype x Delay, $F(1, 42) = 10.39$, $p < .01$, and a significant three-way interaction of Testtype x Wordtype x Delay, $F(1, 42) = 15.17$, $p < .01$.

To explore the three-way interaction further, separate analyses of item recognition and associative recognition performance were conducted. For associative recognition, there was a significant main effect of Group, $F(2, 42) = 6.29$, $p < .01$, indicating that the CHI group performed poorer than the control groups. There was also a significant main effect of Delay, $F(1, 42) = 13.89$, $p < .01$, indicating better memory performance on the immediate versus the final test. There was also a significant Wordtype x Delay interaction, $F(1, 42) = 16.87$, $p < .01$; more concrete words were recognized at final test than abstract words. Furthermore, the CHI group showed the same pattern of performance as the control groups, as indicated by a lack of a three-way interaction (i.e., Group x Wordtype x Delay, $F(2, 42) < 1$.

For item recognition, there was a significant main effect for Group, $F(2, 42) = 4.62$, $p < .05$; the CHI group's performance was lower than the control group's performance. There was also a significant main effect for Delay, $F(1, 42) = 46.80$, $p < .01$, more items were recognized on the immediate test compared to the final test. There were no group interactions; again the pattern of performance was the same, only lower for the CHI group.

The three-way interaction obtained in the overall analysis was attributable to differences between concrete and abstract word pairs on the associative recognition test. More specifically, recognition accuracy for concrete word pairs remained stable from the immediate test to the final test, whereas recognition performance for abstract word pairs declined with test delay. By contrast, item recognition performance declined equally for concrete and abstract words from the immediate to the final test.

In summary, the matched control group demonstrated better overall recognition performance than the CHI group (means = 82.4 and 69.6, respectively). However, there were no interactions involving group. Both the matched control and CHI groups performed better on recognition tests for item information (means = 89.7 and 76.9, respectively) compared to associative information (means = 75.1 and 62.4, respectively). The matched control group performed better than the CHI group on both item and associative recognition tests. Overall memory performance was better on immediate recognition than final recognition. Additionally, final associative recognition performance was better for concrete words compared to abstract words.

Metamemory Results

The unmatched group was not considered further as their performance did not differ from that of the matched group. Further analyses of results only compared the matched control group (hereafter referred to simply as the control group) to the CHI group.

Predictions

Since prediction ratings were made only after each studied word pair for three study lists, a 2 (Groups:

Control, CHI) x 2 (Wordtype: Concrete, Abstract) X 3 (Study-List) mixed model analysis of variance was used to analyze mean prediction ratings. The data are reported in Table 2.

It was hypothesized that the CHI group would give higher prediction ratings than the control group. However there was no significant main effect of Group, $\underline{F}(1, 28) < 1$. Analysis of Study-List revealed that predictions were higher for List 2 than List 1, $\underline{F}(1, 28) = 8.25$, $\underline{p} < .01$, however predictions for List 2 and List 3 did not differ, $\underline{F}(1, 28) = 1.15$, $\underline{p} = .292$. Further analysis revealed a significant interaction for Wordtype x Study-List for List 1 versus 2, $\underline{F}(1, 28) = 6.52$, $\underline{p} < .05$, but not for List 2 versus List 3, $\underline{F}(1, 28) < 1$; mean prediction ratings increased more for concrete words than abstract words from List 1 to 2 but not from List 2 to 3.

In summary the groups did not differ in the overall prediction ratings they made. It was hypothesized that the CHI group would give higher prediction ratings. Since there was no difference between the groups' prediction ratings but there was a significant difference between the groups' recognition performance, with the control group performing better than the CHI group, this suggests that the CHI group overestimated their performance or the controls underestimated their performance. Prediction ratings increased from List 1 to 2 but not from List 2 to 3.

Table 2

Mean Prediction Ratings and Standard Deviations (SD) for Concrete and Abstract Words for Study-Lists 1, 2, and 3 for the Control and CHI Groups.

	Concrete			Abstract		
	Study Lists			Study Lists		
	1	2	3	1	2	3
Control	3.0	3.4	3.5	3.1	3.4	3.5
SD	0.86	0.83	0.92	1.0	0.88	0.96
CHI	3.0	3.3	3.4	3.0	3.2	3.3
SD	1.02	1.13	0.94	1.05	1.13	0.99
MEAN (N = 30)	3.0	3.4	3.5	3.1	3.3	3.4
SD	0.93	0.98	0.92	1.01	1.01	0.96

Furthermore, prediction ratings for both abstract and concrete words increased from List 1 to 2, with the increase in ratings being greater for concrete words than for abstract words.

Postdictions

A mixed model analysis of variance was used to analyze postdiction ratings for the two groups (GROUP), for item and associative information (TESTTYPE) with concrete and abstract words (WORDTYPE) for immediate and final tests (DELAY). Means are reported in Table 3.

It was hypothesized that there would be no difference between the control and CHI groups' postdiction ratings. This hypothesis was supported by the results. There was no significant Group difference, $F(1, 28) = 3.01$, $p = .094$, and there were no significant interactions involving Group. The main effect of Wordtype was not significant, $F(1, 28) < 1$. There were two significant main effects, Testtype, $F(1, 28) = 5.32$, $p < .05$, and Delay, $F(1, 28) = 16.96$, $p < .01$. Mean postdiction ratings for associative recognition ($M = 3.7$) were higher than postdiction ratings for item information ($M = 3.5$). The mean postdiction ratings for immediate recognition ($M = 3.8$) were also higher than final recognition postdictions ($M = 3.5$).

Table 3

Mean Postdiction Ratings and Standard Deviations (SD) for Item and Associative Recognition of Concrete and Abstract Words on Immediate and Final Tests for the Control and CHI Groups.

	Item Postdiction				Associative Postdiction			
	Immediate		Final		Immediate		Final	
	Con	Abs	Con	Abs	Con	Abs	Con	Abs
Control	4.0	4.0	3.6	3.4	4.1	4.1	4.1	3.8
SD	0.98	0.87	1.02	0.92	0.83	0.84	0.90	1.0
CHI	3.4	3.4	3.1	3.2	3.5	3.5	3.4	3.2
SD	1.07	0.90	0.91	0.98	1.05	0.82	1.[illegible]8	1.07

There was a significant interaction of Testtype x Delay, $F(1, 28) = 4.97$, $p < .05$. Mean postdiction ratings for item and associative performance on immediate recognition were 3.7 and 3.8, respectively. Mean postdiction ratings for item and associative recognition declined on the final test; however, postdiction ratings for item recognition declined more from immediate recognition ($M = 3.7$) to final recognition ($M = 3.3$), than postdictions for associative recognition which declined less from the immediate test ($M = 3.8$) to the final test ($M = 3.6$).

There was also a significant interaction of Wordtype x Delay, $F(1, 28) = 4.19$, $p < .05$. Postdiction ratings did not differ for wordtypes (i.e., concrete and abstract words) on immediate recognition ($M = 3.8$, for both wordtypes). However on final recognition, overall mean postdiction ratings for concrete words was 3.6, a difference of .2 from immediate recognition. Differentially, on the final recognition test, the mean postdiction rating for abstract words was 3.4, a difference of .4 from immediate memory. Thus, postdiction ratings for abstract words declined more than those for concrete words.

Further analyses were conducted using the analysis of variance procedure to investigate postdiction ratings for item recognition and associative recognition separately. Groups did not significantly differ from each other for postdiction ratings for item recognition, $F(1, 28) = 2.38$,

p =.134, or for associative recognition, $F(1, 28) = 3.52$, p =.071. Furthermore, postdiction ratings for item and associative recognition were higher following immediate recognition than final recognition, $F(1, 28) = 21.51$, p <.01 and $F(1, 28) = 4.75$, p <.05, respectively. There was a significant interaction of Wordtype x Delay for postdictions made for associative recognition (but not for item recognition), $F(1, 28) = 8.02$, p <.01; postdictions made for abstract words (but not concrete words) were lower on the final test compared to the immediate test.

In summary, there were no significant differences between the groups' postdiction ratings. Thus, although the control group performed better on the recognition tests than the CHI group, their postdiction ratings did not differ. Also, in contrast to their actual performance, both groups gave higher ratings for associative recognition than for item recognition. However, postdiction ratings for both groups were in agreement with their actual recognition performance in the following respects. Higher postdiction ratings were given for the immediate test versus the final test, and postdictions on the final test declined more for item recognition than postdictions made for associative recognition. Postdictions on the immediate recognition test did not differ for concrete and abstract words. By contrast, final recognition test postdictions for concrete words declined less than postdictions for abstract words.

Furthermore, postdictions made for abstract words (but not for concrete) declined for associative recognition on the final test.

Correlations

Predictions and Postdictions

Pearson *r* correlations were conducted to determine the relationship between mean prediction and postdiction ratings for both groups. There was a significant correlation of mean prediction and postdiction ratings for the control group, $r = 0.75$, $p < .01$. The CHI group also had a significant correlation of mean prediction and postdiction ratings, $r = 0.87$, $p < .01$. These correlations indicate a strong relationship between confidence ratings of how individuals report they will perform (predictions) and their confidence ratings of how they think they have performed (postdictions). Thus both groups demonstrated a strong relationship between their memory monitoring judgements at time of encoding (predictions) and at time of retrieval (postdictions).

To determine whether individuals were sensitive to the differences between concrete and abstract material, the relationship between their confidence in their ability to recognize these wordtypes prior to test (predictions) and after test (postdictions) was examined. Both groups showed a strong relationship between prediction and postdiction ratings for both concrete and abstract words. For the control group, there was a significant correlation of mean concrete prediction and concrete postdiction ratings, $r = 0.69$, $p < .01$, as well as a significant correlation of mean abstract prediction and abstract postdiction ratings, $r = 0.76$, $p < .01$. For the CHI group, there was a significant correlation of mean concrete prediction and concrete postdiction ratings, $r = 0.84$, $p < .01$, as well as a significant correlation of mean abstract prediction and abstract postdiction ratings, $r = 0.87$, $p < .01$. Although there were consistent correlations between prediction and postdiction ratings for concrete and abstract stimuli, these relationships should be interpreted with caution. Factors which may have influenced these relationships are the limited range of the confidence rating scale (i.e., 1 to 5) and the tendency of participants from both groups to choose ratings on the midpoint of the scale. It should be noted that the influence of these factors would work against finding a reliable relationship.

Prediction and Proportion Correct

An individual's confidence in their ability to recognize a target in the future may differ from their ability to recognize the target. To determine the relationship between confidence ratings of future recognition and actual recognition, Pearson *r* correlations of mean prediction ratings and proportion of correct recognition responses were conducted.

Neither group had significant correlations between their mean prediction ratings and mean proportion of correct recognition; furthermore these non-significant relationships were independent of wordtype. This implies that neither group's level of confidence in their future recognition ability was consistent with their actual proportion of correct recognition responses.

In summary there were no significant relationships between predictions and actual recognition performance, nor did wordtype (i.e., whether the word was concrete or abstract) influence predictions.

Postdiction and Proportion Correct

An individual's confidence based on the correctness of their response may be different from how they actually perform. To determine the relationship between postdiction ratings and proportion of correct recognition responses, Pearson *r* correlations were conducted.

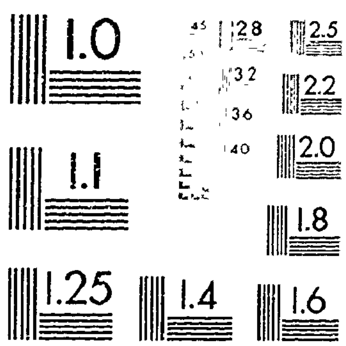
There was a significant correlation of mean postdiction ratings with mean proportion correct for the control group,

$\underline{r} = 0.48$, $\underline{p} < .05$. The CHI group's correlation between mean postdiction ratings and mean proportion correct was not significant, $\underline{r} = 0.31$. $\underline{p} = .128$. These correlations imply that for the control group, but not the CHI group, confidence in performance was significantly related to actual performance.

Correlations of mean postdiction ratings and mean proportion of correct recognition were also considered in terms of the potential influence of wordtype (i.e., whether the word was concrete or abstract). The only significant correlation obtained was for the control group for mean concrete postdiction ratings with mean concrete proportion of correct recognition, $\underline{r} = 0.50$, $\underline{p} < .05$. There were no significant correlations for mean abstract postdictions with mean abstract proportion of correct recognition. This indicates that neither group was able to accurately monitor their memory performance for abstract words at time of retrieval.

Pearson r correlations were used to further examine concrete and abstract postdiction ratings and proportion correct for item and associative information separately. For item recognition, there were no significant correlations between postdiction ratings and proportion of correct recognition for concrete or abstract words for either the control or CHI group.

For associative recognition, there was a significant


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

correlation of mean concrete postdiction ratings with mean proportion of concrete associative recognition for the control group, r = 0.51, p <.05; the CHI group's correlation was not significant, r = 0.25, p =.188. The control group's correlation of mean abstract postdiction ratings for associative recognition with the mean proportion correct for abstract associative recognition was also significant, r = 0.56, p <.05; the CHI group's correlation was not significant, r = 0.10, p =.355.

In summary, concrete and abstract postdictions and mean proportion correct for type of information (i.e., item and associative), revealed significant correlations but only for the control group. The control group's postdiction ratings for both abstract and concrete words significantly correlated with abstract and concrete associative recognition.

Overall, neither group showed a significant relationship between prediction and recognition performance. The control group, but not the CHI group, was better able to monitor their recognition memory at time of retrieval, but this was true only for associative recognition tests.

Discussion

Neuropsychological Tests

The neuropsychological assessments were conducted as part of the hospital routine referrals of the CHI patients (assessments were also obtained for the control group for data analysis purposes). They were used to determine specific functions that differed significantly between the groups. Overall, the neuropsychological assessments indicated significant differences between the CHI group and control group's present level of cognitive functioning. These differences cannot be attributed in large measure to disparities between the control and premorbid CHI group's cognitive function because the overall NART scores did not greatly differ between the groups.

It should be noted that performance on the NART has been shown to be resistant to deterioration in participants with dementia (O'Carroll, Baike, & Whittick, 1987; Sharpe & O'Carroll, 1991), depression (Crawford, Benson, Parker, Sutherland, & Keen, 1987), and head injury (Crawford, Benson, & Parker, 1988). Crawford et al. (1988) compared the performance of eighteen closed-head injured patients to eighteen normal control participants matched for gender, age and level of education. There were no significant differences between the groups' NART scores. Furthermore, Moss and Dowd (1991) reported a case study in which a head-injured individual was administered an intelligence test during childhood (premorbid) and who later sustained a head injury; premorbid estimates of intellectual ability obtained using the NART revealed an accurate estimate of his pre-injury IQ; this was substantiated by his actual premorbid IQ scores.

Collectively, these studies suggest that the NART has validity as a measure for estimating premorbid intellectual functioning in clinical groups such as CHIs. However, it is also possible that the NART scores may be influenced by the effect of diffuse brain injury. In the present study, scores obtained using the NART revealed no differences between the groups' premorbid level of functioning on the FSIQ and VIQ scales (though these scores approached significance), however a significant difference was obtained for performance IQ between the groups. This finding suggests that diffuse brain injury may influence, to some extent, premorbid intelligence scores. As the groups were otherwise matched, this precludes the possibility that the NART scores were a result of population characteristics. The present study may have obtained differences not observed in the Crawford et al. study because mild and moderate CHI patients were tested whereas Crawford et al. did not provide classifications for their CHI sample and it is possible that their sample included more mild CHI patients.

In addition to indicating differences in overall cognitive functioning, performance on the neuropsychological tests also indicated that the CHI group's impairments were not localized. For example, the CHI group had lower verbal fluency performance, an impairment usually associated with frontal lobe damaged patients (Lezak, 1983). Additionally, the CHI group's performance on both logical memory tests (I & II) indicates left temporal damage (Beaumont, 1983; Lezak, 1983), while impaired performance on the Rey delayed test suggests right temporal lobe damage (Beaumont, 1983). These results support the diffuse nature of the CHI group's impairments.

Furthermore, the CHI group's pronounced impairment on tests of delayed memory (i.e., Logical Memory II and Rey Complex Figure-delay) is consistent with Brooks' (1975) findings that patients with diffuse brain damage perform significantly poorer on delayed tests of recall than control groups.

Item and Associative Recognition

Overall recognition performance was significantly greater for the control group compared to the CHI group. Notably, the CHI group's pattern of performance was comparable to that of the normal control group. Similar findings by Levin and Goldstein (1986) and Goldstein et al.

(1990) support the suggestion that the difference in performance between head-injured groups and normal control groups may be quantitative rather than qualitative for certain tasks. In these studies performance patterns for processing of different types of information were the same for the CHI and control groups, with only a difference in level of performance.

It was hypothesized that the control group (but not the CHI group) would exhibit a concreteness effect (i.e., significantly greater recognition of concrete material over abstract material) for both types of information (i.e., item and associative). This hypothesis was partially supported. For item recognition neither group demonstrated the normal memory superiority for concrete over abstract words; this was contrary to previous findings (Paivio, 1971, 1986; Richardson, 1979a; Richardson & Snap, 1984). The lack of an advantage in memory for item recognition of concrete words was expected for the CHI group but not for the control group (Richardson, 1979a; Richardson & Snap, 1984).

Two explanations are suggested for the absence of a concreteness effect for item recognition for the control group. Firstly, some characteristics of the matched control population (e.g., age, education level) may have influenced performance, thus contributing to the absence of the concreteness effect. This explanation does not seem very likely given the fact that the unmatched control group who were younger and had a higher education level (which seem more characteristic of control groups used in previous research of memory for concrete and abstract words [Nelson & Schreiber, 1992; Paivio, 1971; 1986; Paivio, Clark, & Khan, 1988; Schwanenflugel, Akin, & Wei-Ming Luh, 1992]) revealed the same pattern of performance (i.e., an absence of the concreteness effect).

Secondly, although the stimulus difference between concrete and abstract words was comparable to previous studies (e.g., Richardson, 1979a), the control group's failure to demonstrate a concreteness effect may have occurred because the difference between concrete and abstract words was not great enough. The fact that there were no differences in the prediction ratings of abstract and concrete word pairs lends support to this proposition.

One aspect of the results, though, is not consistent with this explanation. While a concreteness effect was not found for item recognition or for immediate associative recognition, a concreteness effect was observed for final associative recognition. This implies that a distinction was made between the two types of stimulus material. If no distinction was made, then the same overall pattern of performance observed for item recognition should have occurred for associative recognition. Therefore, this explanation, though possible for item recognition, is not consistent with the final associative recognition performance. Thus, it is not clear why both control groups did not show a concrete word advantage in item recognition.

The advantage in delayed memory for concrete associative recognition observed for the CHI group was not expected. Levin and Goldstein's (1986) study may provide a partial explanation of this finding. They demonstrated that CHI patients have a partially preserved ability to process information semantically. In particular, Levin and Goldstein (1986) observed that when words belonging to a common category were presented, CHI individuals demonstrated better recall than when unrelated words and words that belonged to different conceptual categories were presented. It seems reasonable to suggest that in the present study the CHI group may have been able to employ elaborative strategies involving attention to semantic features (e.g., verbal elaboration) for concrete word pairs, but may have been unable to effectively do the same for abstract word pairs which resulted in an advantage in forming associations between concrete words. This advantage, while not apparent on the immediate test, did emerge on the final test. Levin and Goldstein (1986) found that, like normals, CHI patients benefit from semantic processing in a cued recall task which involves associative information. The present results for associative recognition show a similar pattern in that the performance of the CHI group was qualitatively the same as the control group. This result may suggest that an important component in forming associations is semantic processing and this processing is easier for concrete than for abstract pairs. Consequently, memory for concrete pairs may be more resistant to forgetting than memory for abstract pairs.

Previous research by Hockley (1991; 1992) demonstrated that associative information was less susceptible to decay and interference than item information. Interference depends on the similarity of the to-be-remembered information and the interfering information (i.e., other words from the list); as similarity increases, the amount of interference increases (Hockley, 1991). Hockley (1992) suggested that the encoded information representing the relationship between items (associative) is in some way more distinctive or less similar to the interfering information.

In view of the present findings, it seems that the forgetting rate of associative information is influenced by the nature of the stimuli. The results of the final associative recognition test showed that there was no forgetting of concrete word pairs, however there was a significant decline in recognition of abstract word pairs. Murdock and Hockley (1989, Exp. 2) compared noun pairs and non-noun pairs in an associative recognition test. For both types of pairs they found no forgetting, although overall performance was greater for the noun pairs. It is not clear why Murdock and Hockley did not find forgetting of non-noun pairs, which consist of abstract words, whereas in the present study forgetting of abstract word pairs was found. What is clear is that consideration of stimulus characteristics is important in associative recognition and further examination of stimulus variables is needed.

Metamemory

The memory and metamemory relationship still remains controversial (Brown, 1978; Chi, 1983; Prevy et al., 1988). While Cavanaugh and Perlmutter (1982) doubt there is a relationship between memory performance and metamemory, Schneider (1985) and Schneider and Pressley (1989) suggest that a relationship exists. The findings from the present study suggest that the relationship between metamemory and memory may be influenced by the component of metamemory under investigation (prediction, postdiction), as well as certain task demands (e.g., type of recognition [i.e., item and associative]).

Metamemory, in particular memory monitoring, for the CHI and control group was assessed using prediction and postdiction ratings. One aim of the present study was to ascertain whether CHI individuals can effectively monitor their encoding and retrieval of information. This was determined by the relationship between memory performance and prediction ratings, and between memory performance and postdiction ratings. The findings from the present study indicated no group differences for prediction ratings. Individuals' confidence in their ability to recognize information in the future (prediction) was not related to their recognition performance. Both groups tended to give ratings around the midpoint of the prediction rating scale (i.e., 3), which is equivalent to a 50% chance that they would recognize the learned material later on. The control group's prediction ratings were consistent with previous research which has indicated that control groups tend to be conservative in their prediction ratings. Prediction ratings and memory performance do not appear to be highly correlated (BharrathSingh, 1992; Lovelace, 1984). By contrast, the literature indicates that brain-injured populations tend to overestimate their memory performance (Janowsky et al., 1989a; Parkin et al., 1988; Prevy et al., 1988).

Research indicates that patients with frontal lobe impairment (Janowsky et al., 1989a; Parkin et al., 1988) and temporal lobe impairment (Prevey et al., 1988) tend to overestimate their ability to recall information. This tendency to overestimate has been associated with lack of insight into their deficit (Janowsky at al., 1989a; Prevey et al., 1988) and difficulty in accurately assessing task demands and utilizing learning strategies (Prevey et al., 1988). However, it should be noted that overestimation of memory performance by the temporal and frontal lobe lesioned populations may be attributed to either their poorer memory performance or higher ratings of memory performance compared to the control group. It seems more reasonable to suggest however, that a combination of poor performance and higher confidence ratings of memory performance would result in overestimation.

In the present study, the CHI group did not have higher predictions relative to the normal controls. This difference between CHI patients and the above brain-injured populations may be accounted for by several factors. It may be argued that given the nature (i.e., diffuse versus localized) and the severity of the brain damage in the present population (i.e., mild-moderate versus severe), specific temporal and/or frontal lobe impairments were not exhibited. In fact not only was the CHI group's pattern of predictions similar to that of the normal population, but it was also inconsistent with the literature regarding prediction ratings for temporal and frontal lobe patients. This may imply that due to the nature of their brain impairment (diffuse versus localized), closed-head injured individuals may be more aware of their deficits which in turn results in more cautious estimations regarding future performance.

In the present study, both groups failed to demonstrate a significant relationship between prediction and memory performance. However, only the CHI group failed to do so at time of retrieval (postdiction). The control group's confidence in their performance at time of retrieval correlated with their overall performance. Their recognition of abstract and concrete words for associative information correlated significantly with recognition performance. These results have two implications.

Shimamura and Squire (1988) suggested that confidence judgements that follow memory responses may be easier (and more accurate) than predictions about performance that precede memory responses for brain-impaired populations. The present study does not provide any support for this suggestion: there was no relationship between either prediction, or postdiction, and memory performance for the CHI group.

Secondly, these findings suggest that for normals, postdiction ratings may be influenced by both type of word (i.e., concrete or abstract) and type of information (item or associative). This conclusion is supported by the finding that postdiction and recognition performance correlated significantly in the associative recognition context, and by the significant interaction between wordtype and test delay for the postdictions for associative recognition. Postdiction ratings of the CHI population were not affected by testtype or wordtype manipulation. Additionally, the wordtype or testtype manipulation may not have been strong enough to influence postdiction ratings in this population.

In the present study, it was hypothesized that there would be no difference between postdictions made for item and associative information by the control group. This hypothesis was not supported by the results. Participants' confidence at time of retrieval was greater for associative recognition than for item recognition. Furthermore, postdictions for associative recognition were significantly correlated with memory performance fo associative recognition. These results suggest that the control group's confidence in their memory performance post test was more strongly related to their memory performance when it was based on associative versus item information.

One possible explanation for higher confidence for associative recognition may be context effects. For associative recognition, a single word-pair is seen at study while two word-pairs are seen at test (one pair intact and one pair rearranged). The context of the intact pair remains the same at test as it was during study in that the same two words appear at test exactly as they did at study. With item information however, the participant previously learned a word pair, but was tested for half of the word-pair, that is, one word. The context at test changes in two ways; first, the word when tested is no longer in a familiar context (i.e., as part of a pair); and secondly, a totally new word is presented, thus testing for an unstudied word. Given the change in context from study to test, there may also be a corresponding change in confidence regarding performance for item versus associative information. This effect should increase with the delay between study and test. This suggestion is consistent with the findings obtained in the present study, where postdiction ratings declined on final test significantly more for item recognition than associative recognition.

Summary

The findings of the present study can be summarized in five points: (1) Closed-head injured individuals demonstrated the same pattern of performance as normal controls for item and associative recognition on immediate and final tests; (2) The concreteness effect was not apparent for item recognition, but was apparent for delayed associative recognition; (3) The closed-head injured group exhibited the concreteness effect, however this was conditional upon the type of test employed and the time of test; (4) There was no relationship between memory monitoring ability at time of encoding and memory performance, nor was there a relationship between memory monitoring ability at time of retrieval and memory performance, for the CHI group; (5) The present study shows that decline of associative recognition occurs over time for abstract material.

Theoretical and Experimental Implications

One of the motivating factors in the present study was to relate theory and data - an apparent need brought to the forefront of memory research by Murdock (1974) and recently reiterated by Hockley and Lewandowsky (1992). Tulving (1987) has specifically proposed the linking (relating) of memory theory to the findings (data) from investigations of memory performance in head-injured populations. Tulving (1987) suggests that psychometric tests are low in reliability and yield non-analytical information which results in only restating the results - thus the need for a theoretical base within which clinical research can be conducted and interpreted.

The findings of the present study question the generalizability of Hockley's (1991) findings. Prior to the present study, associative recognition was reported to be relatively stable and to experience minimal decay over time (Hockley, 1991; 1992), in contrast to item information. The present study has demonstrated a consistent and clear pattern of decline for associative recognition of abstract word pairs. Given these results, the theoretical distinction between item and associative information may need to be further explored, and the previously held premise that forgetting of associative information seems less susceptible to decay and interference compared to item information should be reconsidered.

Future research may want to consider the conditions under which associative information is resistant to decay and interference or alternatively under what conditions does forgetting occur. A possible point of entry in investigating this would be to manipulate stimuli (e.g., types of words varying in concreteness, abstractness, imagery, familiarity, meaningfulness) to determine their influence and effect on associative information over time.

Additionally, the findings of the present study also question the generalizability of Richardson's (1979a; 1980; Richardson & Snap, 1984) findings regarding the concreteness effect for CHI populations. It is not clear why the concreteness effect occurred for associative recognition but not for item recognition. Future research may want to further investigate associative recognition performance to determine whether the pattern of results obtained for associative recognition in the present study can be replicated. Future research may also consider directly investigating the use and effects of imagery on memory performance in head-injured populations, using a variety of memory tests (e.g., free recall, cued recall, forced choice recognition) to examine the generalizability of any imagery effects.

Clinical Implications

Within the clinical field, the establishment of realistic treatment goals and the assessment of a patient's capacity to benefit from treatment all depend upon information regarding executive functioning and metacognition (Cicerone & Tupper, 1986; Lezak, 1987). If closed-head injured individuals inaccurately monitor their memory processes (i.e., at time of encoding and retrieval), this information can be useful to various professional health care workers in: (1) devising and implementing memory techniques to aid in the rehabilitation and reintegration of the individual back into the community; for example, the use of memory techniques involving associations, in particular concrete associations, as this seems less susceptible to decay; (2) determining the appropriateness of various remedial techniques; and (3) determining the "readiness" of a patient to benefit from remedial techniques or other rehabilitative interventions.

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Appendix A

Screening Form

Screening Form for Control Participants

NAME : ______________________________

Subject # : _____ *DOB* ___/___/___ *Age* ___

Gender _____ *Yrs Education* ___

Occupation ____________________

Alcohol consumption ___*oz/wk* *Smoking* ___ *pks/day*

1. *Have you ever been in a motor vehicle accident, where you may have sustained a bump/injury to your head ?*

   1. NO ___
   2. YES...describe ______________________
   ____
   ____
   ____

2. *Do you take any prescribed or non-prescribed drugs ?*

   1. NO ___
   2. YES...describe ______________________
   ____
   ____
   ____

3. *Have you ever had any serious medical or neurological illness ?*

   1. NO ___
   2. YES...describe ______________________
   ____
   ____
   ____

4. *Have you ever had a CT/ MRI/ PET/ EEG done ?*

   1. NO ___
   2. YES ___

Appendix B

Informed Consent Form

Informed Consent Form

PARTICIPANT NAME ______________________________

INVESTIGATORS : Mate-Kole, C.C., Joyce, B., Hockley, W.E., and BharrathSingh, K.

You are invited to take part in a research investigation at the Nova Scotia Rehabilitation Centre. It is important that you read and understand several general principles that apply to all who take part in our research studies:

(1) Taking part in the investigation is entirely voluntary. If you are a patient, whether you participate or not will not affect the quality of medical care provided to you.

(2) Personal benefit may or may not result from taking part in the investigation, but knowledge will be gained that may benefit others.

(3) You may withdraw from the investigation at any time without loss of benefit to which you are otherwise entitled. Withdrawal from the study will not affect the care you receive.

This study is concerned with the effects of closed-head injury upon memory performance. The neuropsychological tests and the memory task will be administered by a Research Assistant in the Department of Psychology at The Nova Scotia Rehabilitation Centre. The testing will take approximately 1.5 hours. Whenever necessary breaks will be permitted during the testing period.

Whenever the results of a study such as this are reported in medical/scientific journals or at meetings, the identification of those taking part is withheld. Medical records of patients are maintained according to current legal requirements and a patient's chart is only available to the investigator(s) during the study.

Should the information obtained through this investigation be deemed important for your clinical management at a later time, the results will be released to the necessary department only with your informed consent. Should any problems arise with regards to your rights as a participant in this investigation, you should contact Dr. C. Charles Mate-Kole (492-6214).

I have read the explanation about this investigation and have been given the opportunity to discuss it and ask questions. I hereby consent to take part in the study.

________________________________ __________________

Signature of participant
and/or

Date

Signature of significant other | Date

Signature of investigator | Date

Signature of Physician
/Neuropsychologist | Date

Appendix C

Concrete Paired-Associates

Concrete Paired-Associates

HILL	IRON
JAR	LENS
PALM	HOME
HONEY	OCEAN
NURSE	MARKET
ORANGE	HOTEL
HOSPITAL	NEEDLE
KNEE	LAMP
LADY	NOSE
OVEN	PAGE
PARK	NAIL
LEAD	ORGAN
LIVER	PEACH
CAGE	EGG
FACE	CENT
GAS	DAD
DOLL	SUN
BUTTER	ESSAY
DOG	VAN
CAMP	FORK
BENCH	CANOE
DRINK	QUEEN
CRAB	PAPER
DISC	FROG

BLOOD	CANAL
TAPE	FRUIT
DOOR	LION
YARD	CHAIN
DUCK	TENT
CUBE	BATH
FRAME	BARN
CASE	DART
WORM	CHOP
ONION	CIDER
CAR	FAT
EYE	COAT
CUE	TOOL
ANKLE	CHEESE
BLADE	STOOL
COAL	TEAR
BUSH	AXE
STRAW	BAND
WIDOW	BRIDGE
STRIPE	BODY
CATTLE	TEACHER
BLOCK	UNCLE
CHURCH	BOOK
SWORD	BEAST
GIRL	BALL
CAKE	AUNT

BIRD	ARM
ASH	BIN
BRUSH	APPLE
PRUNE	STOVE

Appendix D

Abstract Paired-Associates

Abstract Paired-Associates

ECHO	LEAK
SWIM	TRIP
LIAR	HALF
ENEMY	TITLE
WASH	HEAT
LINE	TOPIC
JUMP	RENT
HURT	GAME
TEMPER	PERIOD
AREA	JOKE
HELP	LOAN
ITEM	HIDE
COLD	TASK
DROVE	THROW
ZONE	YEAR
AGE	BET
DOZEN	NATION
VICE	MALL
LOCK	BASE
DEAL	HERO
SWEEP	FIGHT
CLOSE	STING
FEE	GERM
PEST	ACT

NAVY	CALL
THEFT	PLACE
NOD	BID
HOBBY	CLASH
UNIT	RIOT
WAR	SUM
DEGREE	AUDIT
GASP	BLUSH
ANSWER	DISPLAY
HUNGER	REWARD
FLASH	RANGE
COUNTRY	INCOME
WIN	REST
FLYER	BUDGET
WINTER	PUZZLE
TERM	CHARM
EXHAUST	ABODE
VACATION	ACCIDENT
UNION	PUBLIC
WEEP	LORD
MURDER	REPORT
REPAIR	NUMBER
MARCH	ANGEL
POETRY	BALLOT
BIRTH	CURVE
SUMMER	ASSEMBLE

Appendix E

Prediction Rating Scale

Prediction Rating Scale

How confident are you that you will remember what you have just learned ?

1) 0%
2) 25%
3) 50%
4) 75%
5) 100%

Appendix F

Postdiction Rating Scale

Postdiction Rating Scale

How confident are you that your response was the correct one?

1) 0%
2) 25%
3) 50%
4) 75%
5) 100%