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Neuropsychological deficits in recovered minor head injury: The contribution of head injury versus post concussion-like symptoms

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Honors Thesis

Louisiana State University

Abstract

A number of people who sustain minor head injury complain of persisting symptoms, such as headache and memory difficulties. This cluster of lingering symptoms is usually referred to as the postconcussion syndrome. The etiology of these symptoms has been attributed to brain damage, psychological/emotional factors, or some combination of the two. This study examined the relationships among head injury, postconcussion symptoms, and neuropsychological deficits by evaluating the performance of symptomatic head injured and non-head injured students and asymptomatic head injured and non-head injured students on a series of neuropsychological tests by using a 2 X 2 factorial design. The predicted results were that if neuropsychological deficits were found in symptomatic head injured students and symptomatic non-head injured students, it would thereby support the hypothesis of a psychogenic basis to the postconcussion symptoms. If neuropsychological deficits were found in both the symptomatic head injured students and the asymptomatic head injured students, a physiological factor would have been supported. If the factors of head injury and symptom preservation interact, a hypothesis of a mixed etiology of both psychogenic and organic factors will be endorsed. The results of this study, however, did not show conclusive data to these three hypothesis perhaps because the homogeneity of the college sample led to a restriction of range.

Neuropsychological deficits in recovered minor head
injury: The contribution of head injury versus
postconcussion-like symptoms

Minor head injury causes alteration in brain function (Montgomery, Fenton, McClelland, MacFlynn, & Rutherford, 1991). A number of people with a minor head injury continue to complain of symptoms long after the initial recovery. This cluster of lingering symptoms is referred to as postconcussion syndrome (Binder, 1986; Gouvier, Cubic, Jones, Brantley, & Cutlip, 1992). The core symptoms which characterize the postconcussion syndrome include headaches, dizziness, irritability, memory and concentration problems, anxiety, fatigue, vision problems, and sensitivity to noise (Binder, 1986, Gouvier et al., 1992, Gouvier, Uddo-Crane, Brown, 1988, & Lishman, 1988). According to Binder (1986), some studies show postconcussion syndrome to continue to affect up to 15% of head injured patients after three years. Oddy, Coughlan, Tyerman, and Jenkins (1985) showed some lasting effects of postconcussion syndrome even after seven years.

The etiology of postconcussion syndrome is controversial. While some authors favor a nonorganic basis for the syndrome such as neurotic behavior, malingering, and anxiety, others view the syndrome as organic in nature (Binder, 1986). Still others hold a combined view such as

that persisting deficits may become pronounced in the presence of stress (Ewing, McCarthy, Gronwall, & Wrightson, 1980).

Organic based hypotheses of the formation of postconcussion syndrome include damage to the brain stem (Binder, 1986; Lishman, 1988). In Rowe and Carlson (1980), symptomatic head injured subjects showed damage to the auditory pathway of the brainstem which possibly accounts for dizziness. Other possible causes with a physiological basis are damage to the temporal and limbic regions by rotational acceleration, prolongation of vasoconstriction and vasomotor dysregulation, arterial spasm, and ischemia (Binder, 1986).

Binder (1986) further urged that postconcussion syndrome symptoms are the result of neurosis and malingering; however, he continued to state that there is no empirical data to uphold the theory that postconcussion syndrome is based on demand of compensation. Previous personality problems and emotional disturbances may be an element to the persisting symptoms (Binder, 1986; Wood, Novack, & Long, 1984). Lishman (1988) noted that the life situations a person is experiencing might effect the response and recovery to a head injury. Rimel, Giordani, Barth, Boll, and Jane (1981) claimed that preinjury stressful events contributed to the development of postconcussion symptoms. Ruesch and Bowman (1945) found

that patients with postconcussion symptoms were similar to non-head injured neurotic patients.

A combined etiology of both an organic and psychogenic nature was supported by findings such as Wood et al. (1984) which shows postconcussion symptoms increase under stress. Minor cognitive deficits with an organic origin may exacerbate the emotional disturbances as well as the reaction to stress (Ewing et al., 1980; Wood et al., 1984). Binder (1986) states, "a stress response syndrome might, in selected cases, explain PCS symptomatology." Gouvier et al. (1992) stated that ability to deal with stress may be lessened due to neuronal damage caused by a mild head injury. Lishman (1988) stated that time governs a relationship between both physiogenic and psychogenic origins of the symptoms such that early symptoms are more organic in nature while symptoms that have longer duration may be linked to a psychological basis.

Leininger, Grambling, Farrell, Kreutzer, and Peck (1990) detected that recovering minor head injury subjects with postconcussion syndrome show neuropsychological deficits supporting the organic factor hypothesis; however, postconcussion symptoms are common among the noninjured population which adds to the controversy (Binder, 1986). The Gouvier et al. study (1988) found that there was no significant difference between the head injured and control subjects concerning the frequency, intensity, and duration of postconcussion syndrome symptoms.

The Leininger et al. study (1990) used symptomatic subjects who had been referred for neuropsychological evaluation and used controls who were not injured. From this data alone, one cannot tell whether it was the history of head injury or the presence of symptoms which account for the neuropsychological test deficits observed in the Leininger et al. study (1990). This study attempted to clarify the results found by Leininger et al. (1990) by adding the control factors of nonsymptomatic subjects with previous head injury and symptomatic subjects without any previous head injury.

Method

Participants

The subjects were 48 college students from a southern university enrolled in undergraduate psychology classes. The subjects included a group of students who have had minor head injuries within the last six years and a group of students without previous head injuries. Minor head injury was classified as a bump to the head that resulted in being dazed for several minutes or losing consciousness up to one hour. The subjects also were grouped according to presence of symptoms associated with postconcussion syndrome.

Perspective subjects were screened by the postconcussion syndrome checklist (Gouvier et al., 1992); the results of this screening were used to classify the subjects as symptomatic or nonsymptomatic. They also were

given the Shipley Institute of Living Scale for purposes of matching group means and establishing a covariate to control for intelligence in the analysis. A demographics questionnaire (see Appendix) was used to obtain information on the subjects background, educational level, and history of head injury. The subjects were those students who scored greater than 72 (symptomatic) or less than 60 (asymptomatic) on the postconcussion symptom checklist. The four groups were the following: Head-injured with symptoms, Head-injured without symptoms, Nonhead-injured with symptoms, and Nonhead-injured without symptoms. Each group consisted of twelve subjects.

Materials

The materials included a series of neuropsychological tests used by Leininger et al. (1990) and an additional measure of neuropsychological functioning. The tests shown effective in Leininger et al. (1990) included the Paced Auditory Serial Addition Task-Revised, the Category Test, Complex Figure:Copy and Memory, and Auditory Verbal Learning Test. This study used the Paced Auditory Serial Addition Task, Rey Auditory-Verbal Learning Test, Complex Figure: Copy and Memory, and the Category Test. The Symbol Digit Modalities Test also was given; in Ponsford and Kinsella (1992), the oral version of this test was indicated as the best measure of information processing deficit.

Procedure

Each subject went through the screening process to allow for grouping. Then, each subject was given a series of neuropsychological tests to evaluate any possible deficits. The tests was given in a fixed order to control for test order although a fixed sequence will not permit identification of any order by group effects. The tests included the following (See Appendix):

Paced Auditory Serial Addition Task (PASAT) (Gronwall, 1977). Subjects heard a list of numbers read on audiotape; they are asked to add each number to the number before it. The rate of each of the four trials became progressively faster.

Rey Auditory-Verbal Learning Test. The procedure was patterned from Savage and Gouvier study (1992) and followed the instructions described in Lezak (1983). The subjects were again asked to recall the words after a 15 minute delay.

Complex Figure Test: Copy Trial (Lezak, 1983). The subjects will be ask to copy a elaborate figure which is scored for accuracy as in the Leininger et al. study (1990).

Complex Figure Test: Memory Trial (Lezak, 1983). After a delay of 15 minutes, the subject were asked to recall the earlier presented figure.

Category Test (Lezak, 1983). The subjects took the short booklet form of this test and were scored by the number of correct responses.

Symbol Digits Modalities Test (Ponsford & Kinsella, 1992). This written test is similar to the Wais Digit Symbol Subtest. In this task symbols were listed that correspond to numbers one through nine, and the subject wrote as many of the corresponding numbers under the symbols as possible in a 90 second time period.

Results

The neuropsychological test performance was compared to evaluate main effects of injury status and symptom complaints, as well as the interaction of these two factors, using a 2 X 2 multivariate analysis of variance (MANOVA) with the standardized score on the Shipley's Institute of Living Scale as a covariate. The Shipley's was used to control for any effects that were based on intelligence differences. Barlett test of sphericity was significant which allowed for the multivariate analysis ($V(21) = 35.82$, $p < .05$). The homogeneity of the sample was confirmed by a nonsignificant result of the Box's M. The interaction between the factors of head injury and symptoms was not significant. The multivariate analysis also showed that there were no significant main effects of either head injury or symptoms.

As this is an exploratory investigation and specific hypotheses were defined in the proposal of this study, 2 X 2 analyses of variance with the Shipley Institute of Living standardized score as a covariate were used to verify each of the three hypotheses.

The results of the Short Booklet Form of the Category Test did not show an interaction between the variables ($F(1,47)=.013$, n.s.). The main effect of head injury did not reach significance ($F(1,47)=1.493$, n.s.). The main effect of symptoms was marginally significant with the symptomatic subjects having greater correct answers on this measure (with symptoms $\bar{M}=74.833$, without symptoms $\bar{M}=69.875$, $F(1,47)=3.250$, $p=.078$).

The Auditory Verbal Learning Test showed a significant interaction between head injury and symptoms ($F(1,47)=6.338$, $p<.05$, See Figure 1). The subjects with head injury and postconcussion-like symptoms did better than the head injured subjects without symptoms. The subjects without prior head injury did better when they did not have the postconcussion-like symptoms. There were no significant main effects of either symptom presence or head injury.

The Rey Complex Figure Memory Trial showed a significant effect in the head injury condition ($F(1,47)=9.329$, $p<.01$). The means indicate that the subjects with a history of head injury performed better than the subjects without a prior head injury (See Figure 2). The main effect of symptoms was marginally significant ($F(1,47)=3.186$, $p=.081$). The subjects with symptoms did better than the subjects without symptoms ($\bar{M}=26.0417$, $\bar{M}=23.4583$, with symptoms and without symptoms respectively). There was not a significant interaction between the variables.

The Symbol Digit Modalities Test did not show a main effect of head injury; however, the effect of symptoms reached marginal significance ($F(1,47)=3.150$, $p=.083$). The subjects who had postconcussion-like symptoms had a mean correct response of approximately 55.7 while the subjects that did not show symptoms had a mean correct response of approximately 51.5. There was not a significant interaction between the variables.

The results of the Paced Auditory Serial Addition Test did not show main effects of either head injury or symptom presence. There also was no interaction observed. The copy trial of the Rey Complex Figure Test did not show any statistical significance nor did the delayed recall measure of the Auditory Verbal Learning Test.

Discussion

The nonsignificant differences among the groups of head-injured and symptomatic students as seen in the initial MANOVA analyses indicate that the extent of the neuropsychological deficits found in the symptomatic head-injured may not be associated to higher functioning individuals. All of the subjects in this study had resumed coursework and were functioning at a level prior to injury. The sample used in the Leininger, et al. study (1990) were minor head injury patients that had been referred for neuropsychological evaluation. Studies by Levin, Mattis, Ruff, et al, Dikmen, McLean, & Temkin, and Gentilini, Nichelli, & Schoenhuber have shown little support of

neuropsychological deficits in most minor head injury patients one month after injury (as cited in Leininger, et al., 1990). The Newcombe, Rabbitt, & Briggs study (1994), which used the PASAT as one dependent measure, found no lingering effects one month post injury. Many people who sustain minor head injury may not suffer neuropsychological dysfunction, but there is an affected subset (Leininger, et al., 1990).

The current study was designed to test specific hypotheses that may be factors for the subset of individuals who do suffer from post concussion syndrome. The possible hypotheses explored were a psychogenic basis to the etiology, an organic basis to the etiology, and a mixed basis to the etiology of this syndrome.

The psychogenic hypothesis would have shown deficits in the symptomatic subjects both with and without prior head injury. This hypothesis was not supported by most of the measures. In each measure that reached at least marginal significance, the symptomatic subjects did better. Perhaps this is due to the type of student who would be considered symptomatic. The subjects knew from the demographics questionnaire that the study was interested in the frequency, duration, and intensity of certain qualities that they had; therefore, the subjects might have been influenced to try harder to compensate for their symptomatology.

The organic based hypothesis stated that deficits would be found in both the symptomatic head injured students and

the asymptomatic head injured students. The subjects with prior head injury had higher correct scores on each of the measures that reached marginally significance. The same factors that influenced the symptomatic subjects may have also had an effect on the head injured subjects as well. They knew that the research was being conducted about people with minor head injury and perhaps knowing influenced the subjects to put forth more effort than the subjects who did not have a personal interest in the research construct.

The mixed etiology hypothesis expected to see an interaction between the variables of head injury and symptom presence. The subjects with head injury and symptoms were expected to perform worse than the subjects with head injury and without symptoms and the subjects without head injury and with symptoms. This hypothesis was not support by the present data.

A cross interaction in the Rey Auditory Verbal Learning Test showed that the subjects without a history of head injury with symptoms did poorer than the subjects without a head injury and without symptoms. The symptom variable did not show a significant main effect; however, this interaction showed that the subjects without prior head injury reacted differently to the postconcussion-like symptoms than the subjects with a history of minor head injury. The subjects with head injury and with symptoms did better than the subjects with head injury and without symptoms. This finding supports that the present results

could be due to the fact that the subjects were aware that the research was based on minor head injury and postconcussion-like symptoms because they were required to report about the symptoms they experienced.

Similar findings by O'Jile (1994) and van Zomeren, Brouwer, Rothengatter, and Snoek (1988) did not show clear cut deficits in the minor head injured subjects on clinical measures. In O'Jile's thesis (1994) which correlated minor head injury to driving performance, the minor head injured subjects did better on the simulated task; however, the actual driving record indicated more violations. This supports the possibility that the results of this study may be an indication of overcompensation of deficits in a high functioning population. The implications of this study show the importance of a practical measure of deficits.

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Appendix

Psychological Tests and Measures

Demographics Questionnaire

The demographics questionnaire contained information about background, education level, and history of head injury. It also contained the measures of the Postconcussion Syndrome Checklist (PCSC) which rates the frequency, intensity and duration of symptoms associated to minor head injury (Gouvier, et al.1992).

Neurological Screening

THIS INFORMATION IS CONFIDENTIAL, AND THE ONLY USE OF THIS DATA WILL BE TO AVERAGE INFORMATION FOR GROUPS OF SUBJECTS.

IF YOU HAVE ANY QUESTIONS REGARDING YOUR ANSWERS, PLEASE ASK THE EXAMINER.

Subject Number: _____ Sex: Male Female
 Age: _____ Race: White Black Other _____
 DOB: _____ Handedness: Right Left Ambidextrous
 Years in School: _____ GPA: _____
 Social Security #: _____

Did you participate in the study on head injury and driving in spring semester, 1993? Yes No

Do you have special accommodations for school work? Yes _____ No _____
 Please specify: _____

How many driving tickets have you had in the last three years? Do not include parking tickets. Please list the date and what happened. _____

Have you ever had a head injury? YES _____ NO _____
 This includes being hit in the head and or hitting your head, and waking up seconds later, or being hit and being dazed for several minutes thereafter.

Have you ever had been hit in the head and been dazed (seeing stars, stunned, or disoriented?) YES _____ NO _____

IF YOU HAVE ANSWERED YES TO EITHER OF THE TWO QUESTIONS ABOVE, PLEASE FOLLOW THE INSTRUCTIONS FOR THE HEAD INJURED SUBJECTS.

IF YOU HAVE NOT HAD A HEAD INJURY, ANSWER THE FOLLOWING QUESTIONS IN SECTION 1. IF YOU HAVE HAD A HEAD INJURY, ANSWER ONLY THE QUESTIONS IN SECTION 2.

ANSWER THE FOLLOWING QUESTIONS IF YOU HAVE NOT HAD A HEAD INJURY.

1A. Rate the frequency of each of the following experiences:

1 = not at all 4 = very often
 2 = seldom 5 = all the time
 3 = often

_____ Headache	_____ Fatigue
_____ Dizziness	_____ Visual disturbance
_____ Irritability	_____ Aggravated by noise
_____ Memory problems	_____ Judgment problems
_____ Difficulty concentrating	_____ Anxiety

Rate the intensity of each of the following experiences:

- 1 = not at all
2 = vaguely present
3 = clearly present
4 = interfering
5 = crippling

_____ Headache	_____ Fatigue
_____ Dizziness	_____ Visual disturbance
_____ Irritability	_____ Aggravated by noise
_____ Memory problems	_____ Judgment problems
_____ Difficulty concentrating	_____ Anxiety

Rate the average duration of each of the following experiences:

- 1 = not at all
2 = a few seconds
3 = a few minutes
4 = a few hours
5 = constant

_____ Headache	_____ Fatigue
_____ Dizziness	_____ Visual disturbance
_____ Irritability	_____ Aggravated by noise
_____ Memory problems	_____ Judgment problems
_____ Difficulty concentrating	_____ Anxiety

1B. Have you ever experienced any of the following physical limitations?
Use the scales from question 1A.

	Frequency	Severity
Clumsiness	_____	_____
Weakness on one side	_____	_____
Other: _____	_____	_____

1C. Have you ever experienced a seizure of any kind? Yes No
IF SO, ANSWER QUESTIONS 1C THROUGH 1G. IF NOT, GO TO QUESTION 1H.

Age at first seizure: _____
Age at seizure disorder diagnosis: _____
Seizure frequency (# per week, month, or year). Please specify: _____

1D. Seizure type(s) - Check all that apply if known:

Partial (focal) seizures:

_____ Simple partial (consciousness not impaired)

Complex partial:

_____ Simple partial onset

_____ Impaired consciousness at onset

_____ Partial seizures evolving into generalized tonic-clonic (GTC)/Grand Mal seizures

	Current amount	Past amount
Alcohol	_____	_____
Marijuana	_____	_____
Cocaine	_____	_____
Amphetamines	_____	_____

Barbiturates _____
Hallucinogens _____

- 1L. If you are a female, how regular is your menstrual cycle? Please comment as necessary.

ANSWER THE FOLLOWING QUESTIONS IF YOU HAVE HAD A HEAD INJURY.

- 2A. How many head injuries have you had? _____
How old were you when these occurred? Please specify for each.

- 2B. For the most recent head injury:

Were you hospitalized: Yes No

Length of hospitalization (number hours or days): _____

Did you have a headach within 24 hours of your injury? _____

- 2C. Did you lose consciousness following your last head injury?

Yes _____ No _____

- 2C. Duration of loss of consciousness for last head injury (Please circle one):

- | | |
|-----------------------------|-------------------------|
| 0. None | 4. 1 hour to 11 hours |
| 1. 1 to 59 seconds | 5. 12 hours to 23 hours |
| 2. 1 minute to 9 minutes | 6. 24 hours to 7 days |
| 3. 10 minutes to 59 minutes | 7. more than 7 days |

- 2D. After a head injury, many people have trouble remembering things for a period of time just before and/or just after the injury, rate the duration of memory loss for the last head injury (use the scale from question 2C):

Before injury: _____ After injury: _____

- 2E. Type of most recent head injury: _____ Closed (nonpenetrating)
_____ Open (penetrating)

- 2F. What was the cause of your last head injury (check one):

- _____ Motor vehicle accident
_____ Fall
_____ Assault
_____ Sporting injury
_____ Other (explain) _____

2G. Rate the frequency of each of the following experiences:

- 1 = not at all 4 = very often
 2 = seldom 5 = all the time
 3 = often

	Current	Before the injury (if less than 5 yrs ago)
_____ Headache	_____	_____
_____ Dizziness	_____	_____
_____ Irritability	_____	_____
_____ Memory problems	_____	_____
_____ Difficulty concentrating	_____	_____
_____ Fatigue	_____	_____
_____ Visual disturbance	_____	_____
_____ Aggravated by noise	_____	_____
_____ Judgment problems	_____	_____
_____ Anxiety	_____	_____

Rate the intensity of each of the following experiences:

- 1 = not at all
 2 = vaguely present
 3 = clearly present
 4 = interfering
 5 = crippling

	Current	Before the injury (if less than 5 yrs ago)
_____ Headache	_____	_____
_____ Dizziness	_____	_____
_____ Irritability	_____	_____
_____ Memory problems	_____	_____
_____ Difficulty concentrating	_____	_____
_____ Fatigue	_____	_____
_____ Visual disturbance	_____	_____
_____ Aggravated by noise	_____	_____
_____ Judgment problems	_____	_____
_____ Anxiety	_____	_____

Rate the duration of each of the following experiences:

- 1 = not at all
 2 = a few seconds
 3 = a few minutes
 4 = a few hours
 5 = constant

	Current	Before the injury (if less than 5 yrs ago)
_____ Headache	_____	_____
_____ Dizziness	_____	_____
_____ Irritability	_____	_____
_____ Memory problems	_____	_____
_____ Difficulty concentrating	_____	_____
_____ Fatigue	_____	_____
_____ Visual disturbance	_____	_____
_____ Aggravated by noise	_____	_____
_____ Judgment problems	_____	_____
_____ Anxiety	_____	_____

- 2H. Have you ever experienced any of the following physical limitations?
Use the frequency scales from question 1A.

	Current	Before the injury (if less than 5 yrs ago)
Clumsiness	_____	_____
Weakness on one side	_____	_____
Other: _____	_____	_____

- 2I. Have you ever experienced a seizure of any kind? Yes No
IF SO, ANSWER QUESTIONS ²¹~~21~~ ²²~~22~~ THROUGH ²³~~23~~ IF NOT, GO TO QUESTION ²⁴~~24~~
Age at first seizure: _____
Age at seizure disorder diagnosis: _____
Seizure frequency (# per week, month or year). Please specify: _____

- 2J. Seizure type(s) - Check all that apply if known:

Partial (focal) seizures:

_____ Simple partial (consciousness not impaired)

Complex partial:

_____ Simple partial onset

_____ Impaired consciousness at onset

_____ Partial seizures evolving into generalized tonic-clonic (GTC)/Grand Mal seizures

Generalized seizures (convulsive or nonconvulsive):

_____ Absence

_____ Myoclonic

_____ Clonic

_____ Tonic

_____ Tonic-clonic (Grand mal)

_____ Atonic

_____ Combinations:

_____ Unclassified (explain): _____

- 2K. Describe a typical seizure: _____

- 2L. Cause of seizure(s) - check one:

_____ Metabolic/hormonal

_____ Cerebral palsy

_____ Febrile seizure

_____ Vascular

_____ Alcohol/drugs

_____ Central Nervous System Infection

_____ Obstetric complications

_____ Family history of seizures

_____ Unknown (explain) _____

- 2M. Seizure medication(s) - check all that apply:

	Current	Past
Phenytoin/Dilantin:	_____	_____
Carbamazepine/Tegretol:	_____	_____
Valproic acid/Depakote:	_____	_____
Phenobarbital:	_____	_____
Other:	_____	_____
No meds:	_____	_____

2N. Have you ever experienced a central nervous system (CNS) disease?
Yes _____ No _____

If yes,

When: _____

What type (if known): _____

Types of treatment: _____ Non-invasive (medication, etc.)
_____ Invasive (surgery, etc.)

2O. Have you ever had a stroke? Yes No If so, when: _____
Type of stroke (if known): _____

2P. Have you ever received electroconvulsive shock therapy? Yes No
When: _____ Reason: _____

2Q. Have you ever used alcohol or drugs? Yes No
Type of drug, when used - check all that apply. Indicate amount used (# of drinks per week, month, or year). Please specify.

	Current amount	Past amount
Alcohol	_____	_____
Marijuana	_____	_____
Cocaine	_____	_____
Amphetamines	_____	_____
Barbiturates	_____	_____
Hallucinogens	_____	_____

2R. Has your appetite changed since your most recent head injury? Please comment as necessary.

2S. If your head injury within the last five years, has your sex drive changed since your accident? _____

2T. If you are a female, did your menstrual cycle change after having your head injury? Please comment as necessary. _____

The Shipley Institute of Living Scale

SHIPLEY INSTITUTE OF LIVING SCALE

Administration Form

Walter C. Shipley, Ph.D.

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Los Angeles, California 90025

Name: _____ Sex: M F Age: _____

Education: _____ Usual Occupation: _____ Today's Date: _____

Part I

Instructions: In the test below, the first word in each line is printed in capital letters. Opposite it are four other words. Circle the *one word* which means the *same thing*, or most nearly the same

thing, as the first word. If you don't know, guess. Be sure to circle the *one word* in each line that means the same thing as the first word.

EXAMPLE:

LARGE

red

big

silent

wet

- | | | | | |
|-----------------|-------------|------------|------------|-------------|
| (1) TALK | draw | eat | speak | sleep |
| (2) PERMIT | allow | sew | cut | drive |
| (3) PARDON | forgive | pound | divide | tell |
| (4) COUCH | pin | eraser | sofa | glass |
| (5) REMEMBER | swim | recall | number | defy |
| (6) TUMBLE | drink | dress | fall | think |
| (7) HIDEOUS | silvery | tilted | young | dreadful |
| (8) CORDIAL | swift | muddy | leafy | hearty |
| (9) EVIDENT | green | obvious | skeptical | afraid |
| (10) IMPOSTOR | conductor | officer | book | pretender |
| (11) MERIT | deserve | distrust | fight | separate |
| (12) FASCINATE | welcome | fix | stir | enchant |
| (13) INDICATE | defy | excite | signify | bicker |
| (14) IGNORANT | red | sharp | uninformed | precise |
| (15) FORTIFY | submerge | strengthen | vent | deaden |
| (16) RENOWN | length | head | fame | loyalty |
| (17) NARRATE | yield | buy | associate | tell |
| (18) MASSIVE | bright | large | speedy | low |
| (19) HILARITY | laughter | speed | grace | malice |
| (20) SMIRCHED | stolen | pointed | remade | soiled |
| (21) SQUANDER | tease | belittle | cut | waste |
| (22) CAPTION | drum | ballast | heading | ape |
| (23) FACILITATE | help | turn | strip | bewilder |
| (24) JOCOSE | humorous | paltry | fervid | plain |
| (25) APPRISE | reduce | strew | inform | delight |
| (26) RUE | eat | lament | dominate | cure |
| (27) DENIZEN | senator | inhabitant | fish | atom |
| (28) DIVEST | dispossess | intrude | rally | pledge |
| (29) AMULET | charm | orphan | dingo | pond |
| (30) INEXORABLE | untidy | involatile | rigid | sparse |
| (31) SERRATED | dried | notched | armed | blunt |
| (32) LISSOM | moldy | loose | supple | convex |
| (33) MOLLIFY | mitigate | direct | pertain | abuse |
| (34) PLAGIARIZE | appropriate | intend | revoke | maintain |
| (35) ORIFICE | brush | hole | building | lute |
| (36) QUERULOUS | maniacal | curious | devout | complaining |
| (37) PARIAH | outcast | priest | lentil | locker |
| (38) ABET | waken | ensue | incite | placate |
| (39) TEMERITY | rashness | timidity | desire | kindness |
| (40) PRISTINE | vain | sound | first | level |

DO NOT WRITE IN THIS AREA

Turn over this sheet and continue with Part II when instructed to do so.

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W-177A

Vocabulary raw score _____

Part II

Instructions: Complete the following by filling in either a number or a letter for each dash (____). Do the items in order, but don't spend too much time on any one item.

EXAMPLE: A B C D E

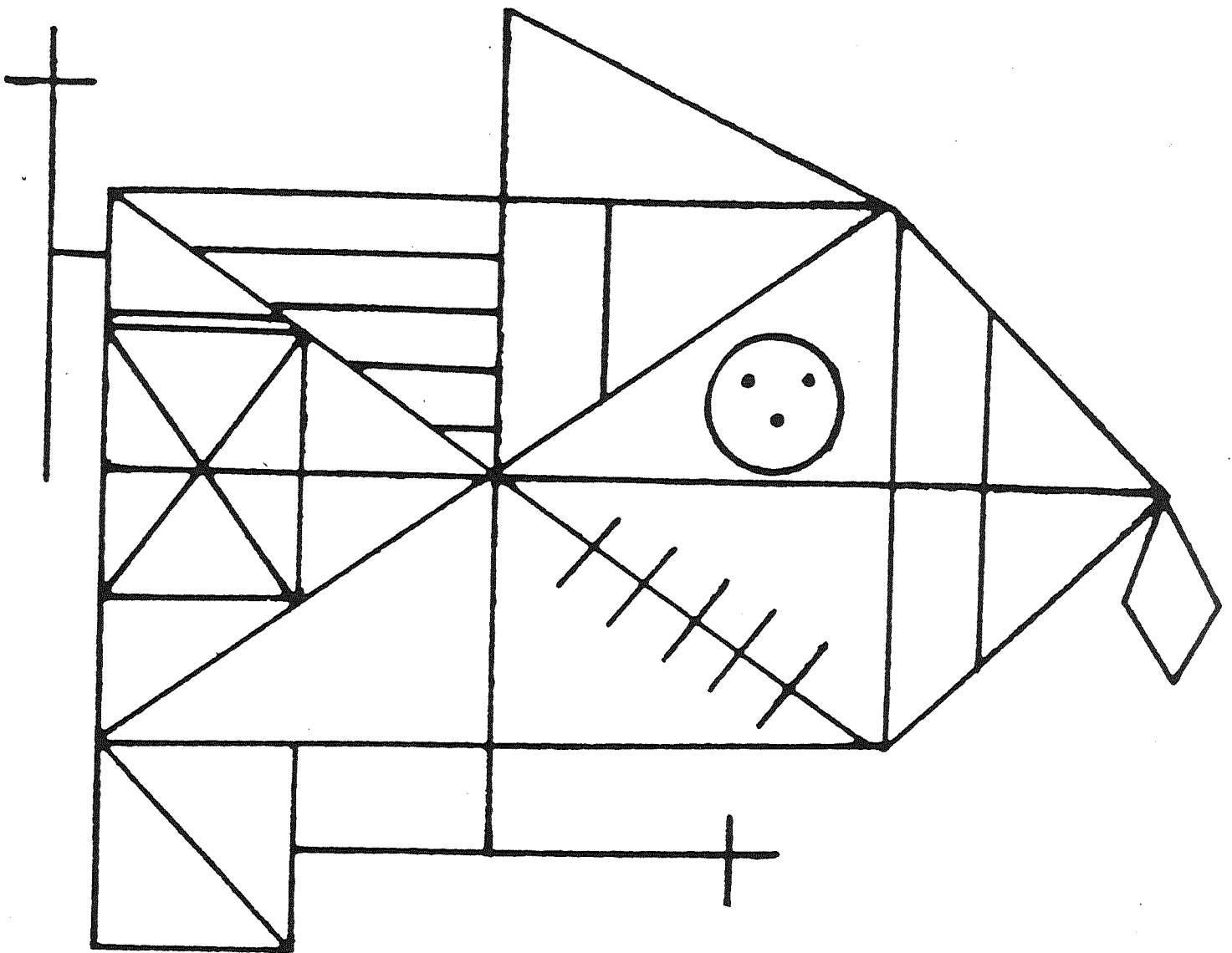
- (1) 1 2 3 4 5 ____
- (2) white black short long down ____
- (3) AB BC CD D ____
- (4) Z Y X W V U ____
- (5) 1 2 3 2 1 2 3 4 3 2 3 4 5 4 3 4 5 6 ____
- (6) NE/SW SE/NW E/W N/ ____
- (7) escape scape cape ____
- (8) oh ho rat tar mood ____
- (9) A Z B Y C X D ____
- (10) tot tot bard drab 537 ____
- (11) mist is wasp as pint in tone ____
- (12) 57326 73265 32657 26573 ____
- (13) knit in spud up both to stay ____
- (14) Scotland landscape scapegoat ____
- (15) surgeon 1234567 snore 17635 rogue ____
- (16) tam tan rib rid rat raw hip ____
- (17) tar pitch throw saloon bar rod fee tip end plank ____ meals
- (18) 3124 82 73 154 46 13 ____
- (19) lag leg pen pin big bog rob ____
- (20) two w four r one o three ____

Summary Scores

V: Raw ____ T ____ A: Raw ____ T ____ Total: Raw ____ T ____
CO: ____ AO: ____ FO: ____

Abstraction raw score ____

Rey Complex Figure Test -- Copy Trial
Rey Complex Figure Test -- Memory Trial (Lezak, 1983)



Scoring for the Rey Complex Figure Copy and Memory Trials
(Lezak, 1983)

1. Cross upper left corner, outside of rectangle
2. Large rectangle
3. Diagonal cross
4. Horizontal midline of 2
5. Vertical midline
6. Small rectangle, within 2 to the left
7. Small segment above 6
8. Four parallel lines within 2, upper left
9. Triangle above 2 upper right
10. Small vertical line within 2, below 9
11. Circle with three dots within 2
12. Five parallel lines within 2 crossing 3 lower right
13. Sides of triangle attached to 2 on right
14. Diamond attached to 13
15. Vertical line within triangle 13 parallel to right
vertical of 2
16. Horizontal line within 13, continuing 4 to right
17. Cross attached to 5 below 2
18. Square attached to 2, lower left

Scoring

Correct	placed properly	2 points
	placed poorly	1 point
Distorted or incomplete but recognizable	placed properly	1 point
	placed poorly	1/2 point
Absent or not recognizable		0 points
Maximum		36 points

Category Test -- The Short Booklet Form

Short Category Test, Booklet Format

Answer Sheet

Linda Wetzel, Ph.D., and Thomas Boll, Ph.D.

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Patient's Name	Age	Sex: M F
Occupation	Education (in years)	
Marital Status	Ethnic Background (if other)	
Primary Reason for Evaluation		
Neurological Procedures:	<input type="checkbox"/> Neurological Exam <input type="checkbox"/> EEG <input type="checkbox"/> CAT Scan <input type="checkbox"/> Neurosurgery	
Other		
Place of Examination		
Examiner		
Date Tested		

Item	Subtest 1	Subtest 2	Subtest 3	Subtest 4	Subtest 5	Item
1	1	1	1	1	1	1
2	3	3	3	3	3	2
3	1	1	1	1	1	3
4	4	4	4	4	4	4
5	2	2	2	2	2	5
6	4	4	4	4	4	6
7	1	1	1	1	1	7
8	2	2	2	2	2	8
9	3	3	3	3	3	9
10	2	2	2	2	2	10
11	3	3	3	3	3	11
12	1	1	1	1	1	12
13	4	4	4	4	4	13
14	3	3	3	3	3	14
15	4	4	4	4	4	15
16	2	2	2	2	2	16
17	1	1	1	1	1	17
18	4	4	4	4	4	18
19	1	1	1	1	1	19
20	3	3	3	3	3	20
	Errors	Errors	Errors	Errors	Errors	

Total Raw Error Score _____

T-Score _____

Percentile Rank Equivalent _____

Symbol Digit Modalities Test

Subjects were given 90 seconds to complete as many as possible.

KEY

(÷	┌	┐	└	┘	+)	÷
1	2	3	4	5	6	7	8	9

[illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible]

Rey Auditory-Verbal Learning Test

RAVLT

Name: _____

Date: _____

Examiner: _____

(Note: Do not re-read List A for Recall Trial A6 or A7)

List A	Recall Trials					List B	Recall Trials		
	A1	A2	A3	A4	A5		B1	A6	A7
drum						desk			drum
curtain						ranger			curtain
bell						bird			bell
coffee						shoe			coffee
school						stove			school
parent						mountain			parent
moon						glasses			moon
garden						towel			garden
hat						cloud			hat
farmer						boat			farmer
nose						lamb			nose
turkey						gun			turkey
color						pencil			color
house						church			house
river						fish			river

correct _____

Total A1 to A5 = _____

Trial A6 - A5 = _____

Recognition # targets correctly identified _____

distractors correctly identified _____

Word List for Testing RAVLT Recognition¹

bell (A)	home (SA)	towel (B)	boat (B)	glasses (B)
window (SA)	fish (B)	curtain (A)	hot (PA)	stocking (SB)
hat (A)	moon (A)	flower (SA)	parent (A)	shoe (B)
barn (SA)	tree (PA)	color (A)	water (SA)	teacher (SA)
ranger (B)	balloon (PA)	desk (B)	farmer (A)	stove (B)
nose (A)	bird (B)	gun (B)	rose (SPA)	nest (SPB)
weather (SB)	mountain (B)	crayon (SA)	cloud (B)	children (SA)
school (A)	coffee (A)	church (B)	house (A)	drum (A)
hand (PA)	mouse (PA)	turkey (A)	stranger (PB)	toffee (PA)
pencil (B)	river (A)	fountain (PB)	garden (A)	lamb (B)

¹Source: Lezak (1983). (A) words from list A; (B) words from list b; (S) word with a semantic association to a word on list A or B as indicated; (P) word phonemically similar to a word on list A or B.

Paced Auditory Serial Addition Task (PASAT)

PASAT
Record Form

Name: _____ Age: _____ Date: _____

2														
7 (9)					8 (12)					5 (13)				
5 (12)					7 (15)					4 (9)				
1 (6)					1 (8)					8 (12)				
4 (5)					6 (7)					2 (10)				
9 (13)					3 (9)					1 (3)				
6 (15)					5 (8)					7 (8)				
5 (11)					9 (14)					5 (12)				
3 (8)					2 (11)					9 (14)				
8 (11)					7 (9)					1 (10)				
4 (12)					5 (12)					3 (4)				
3 (7)					3 (8)					6 (9)				
2 (5)					4 (7)					2 (8)				
6 (8)					7 (11)					9 (11)				
9 (15)					1 (8)					7 (16)				
3 (12)					5 (6)					8 (15)				
4 (7)					8 (13)					2 (10)				
5 (9)					3 (11)					4 (6)				
8 (13)					4 (7)					7 (11)				
6 (14)					6 (10)					6 (13)				
4 (10)					8 (14)					3 (9)				

Total Correct

Time/Response

2.4 sec. pacing

2.0 sec. pacing

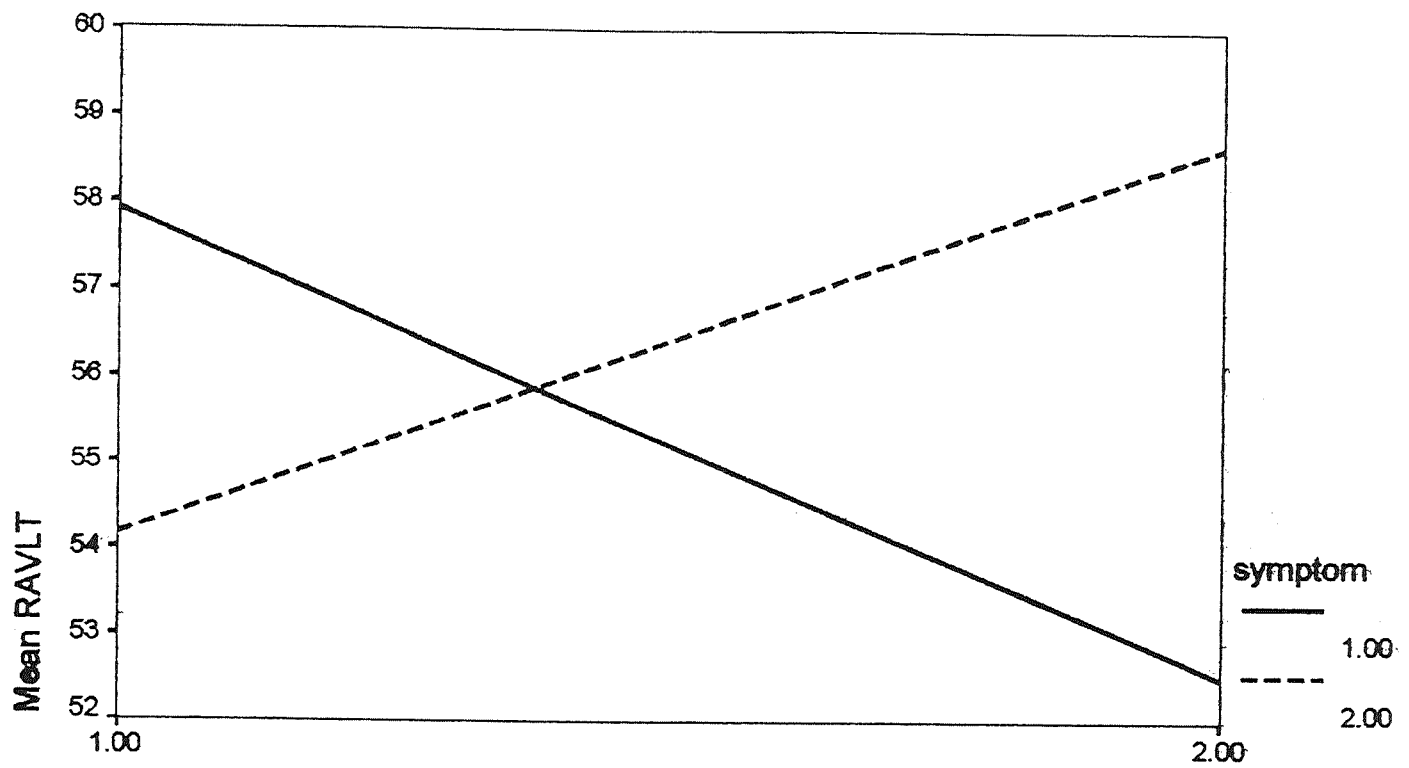
1.6 sec. pacing

1.2 sec. pacing

Total time _____

Mean time _____

Mean Scores on the RAVLT across Head Injury and Symptom Presence



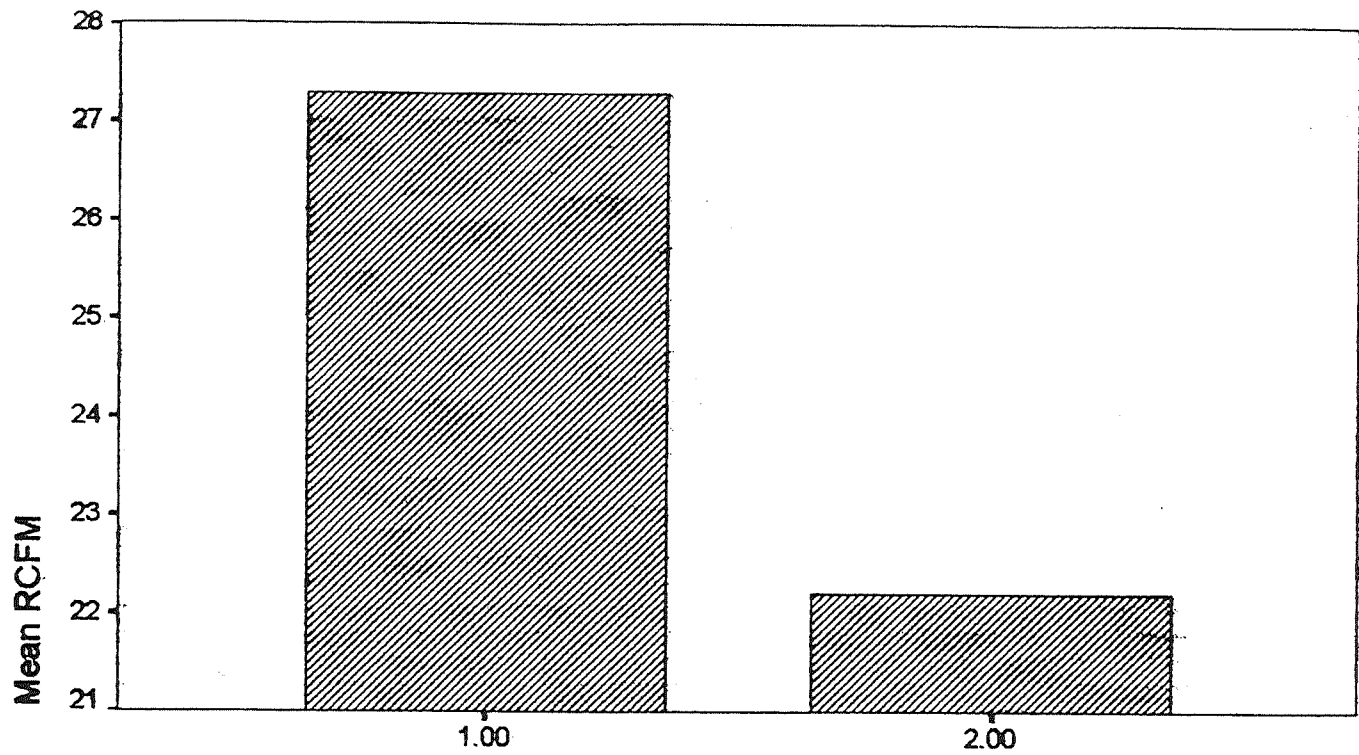
HI

Symptom 1=Symptomatic 2=Nonsymptomatic

HI 1=Head Injury 2=Non-Head Injured

Rey Complex Figure Memory Task

In Head Injured and Non-head Injured Subjects



HI

HI 1=Ss with head injury

2=Ss without head injury

Figure Captions

Figure 1. Mean scores on the Rey Auditory Verbal Learning Test in relation to the conditions of head injury and symptom.

Figure 2. The mean scores of subjects with prior head injury and without prior head injury on the Rey Complex Figure -- Memory Trial