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THE PERFORMANCE OF TRAUMATICALLY BRAIN INJURED ADULTS

ON

TONE PATTERN RECOGNITION TASKS

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee, Knoxville

Cheryl A. Jacobus

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This study was conducted at the Speech/Language and Audiology Department at Fort Sanders Regional Medical Center, Knoxville, Tennessee. The author is grateful to the staff for their cooperation, assistance in locating subjects, and insightful comments.

ABSTRACT

The purpose of this descriptive study was to determine if differences exist in the accuracy between normal subjects and traumatically brain injured subjects on tone pattern tasks. A second and related purpose was to determine if differences exist in accuracy and pattern of performance among cognitive levels 6 - 8 on the Ranchos Los Amigos Scale of Cognitive Levels and Expected Behaviors as described by Hagen and Malkmus (1979). Four traumatically brain injured subjects and four normal subjects listened to an audio tape presentation of two, three, and four tone sequences and marked their answers on a score sheet. The tone pattern recognition task consisted of six subtests each with ten practice items and fifty test items. The results of this study suggest:

1. Traumatically brain injured adults exhibit more difficulty on a tone pattern recognition task than normal adults; and

2. No apparent differences exist in accuracy and patterns of performance among the three cognitive levels used in this study.

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CHAPTER I

INTRODUCTION, REVIEW OF THE LITERATURE, AND STATEMENT OF THE PROBLEM

A. INTRODUCTION

Traumatic brain injury is the term to describe nonpenetrating traumatic injuries of the head that result in cerebral dysfunction. Traumatic brain injury is a significant phenomenon in our society. The incidence is estimated to be 20 per 100,000 population per year. Of all age groups, the fifteen to twenty-four year old group has the highest frequency (Hudson and Ray, 1987). In 1980, the major cause of death of persons in the United States, under the age of thirty-five, was traumatic brain injury (Kalsbeek, McLaurin, Harris, and Miller, 1980). Males have a rate of twice that of females. The major overall cause of traumatic brain injury is motor vehicle accidents (Hudson and Ray, 1987). Economic cost of treating traumatic brain injury is estimated at over four billion dollars per year (Anderson and McLaurin, 1980).

Several authors have written of the effects of a blow to the skull. Brain and Walton (1969) noted that all parts of the brain suffer to an extent. The brain expands within the skull and accelerates, rotates, and compresses on impact, therefore, creating pressure waves within the brain substance (Brain and Walton, 1969; Field, 1970; Walker, Kabros, and Case, 1944).

The cerebral tissue is damaged through the dynamics of compression, tension, and shearing forces (Brain and Walton, 1969; Greenfield and Russell, 1963; Tomlinson, 1964; and Walker, 1944). Contusions, lacerations, and intracranial pressure, are also factors that cause disruption and displacement of brain tissue.

Several authors have reported microscopic alterations of both white and gray matter. According to Brain and Walton (1969), there are minute hemorrhages that occur upon impact throughout the brain. Greenfield (1938) reports severe localized demyelination, while Stritch (1956 and 1961) and Tomlinson (1964) note wide-spread white matter degeneration. Hagen (1983) reported that Courville and

Aymes, and Horowitz observed nerve cell damage in traumatically brain injured patients.

The most frequent handicapping residuals in traumatic brain injury are described as more behavioral than physical in nature consisting of impairments in the three areas of cognition, emotional/social, and communication. The traumatically brain injured individual's communicative impairment results from the combined effects of disorganization and confused language processing (Hagen, 1983).

Hagen (1983) notes that the neuropathological consequences of traumatic brain injury suggest that the initial generalized impairment of language/cognitive processes is the disruption and disorganization of neurophysiological activity. The irreversible neurological damage conversely produces a variety of language/cognition impairments which remain even after the neurological damage decreases.

Therefore, a traumatically brain injured individual's receptive, integrative, and expressive language is characterized by disorientation, disorganization, confusion, stimulus bound, and reduced initiation. This is said to be due to the disruption of the seven cognitive processes (Hagen, 1983):

1. attentional abilities;
2. discrimination;
3. sequential ordering of sensory stimuli and internal thoughts;
4. categorization of sensory stimuli and internal thoughts;
5. memory abilities (retention span, immediate, recent and remote memory);
6. association/integration of sensory stimuli and internal thoughts; and
7. analysis/synthesis of sensory stimuli and internal thoughts.

The speech/language pathologist's evaluation of the traumatically brain injured individual generally includes assessments in the following areas: auditory comprehension, reading comprehension, verbal expression, written expression, articulation, and cognitive functioning. After reviewing the literature on the traumatically brain injured population, it is apparent that few, if any, are assessed in the area of auditory processing, although this area would appear to be a probable deficit in a traumatically brain injured population. Alternately, few writers categorize the brain injury related deficits as an impairment of auditory processing.

Pinheiro and Musiek (1985), Willeford (1985), and others have written about assessment of central auditory processing and its role in communication disorders. There appears to be no agreed-upon "best method" for measuring auditory processing capabilities. Pinheiro and Musiek state that "much research is still needed in the development of a viable clinical procedure" in the areas of auditory and language deficits (p. 235).

B. REVIEW OF THE LITERATURE

Auditory Processing

Pinheiro and Musiek (1985) reviewed the assessment of central auditory processing. The use of a non-language (tone) patterning task was reported as productive. The theoretical basis of the tone pattern/non-speech task is that both speech processing and patterning of non-speech tasks are left hemisphere tasks.

Rice (1980), Muma (1978), and others assume a cognitive base for language. Muma theorizes that one must have cognitive strategies to understand and produce language. The use of a language strategy requires the basic knowledge of the language. According to Peterson, Wallace, and Eby (1987), before the language strategy of a person is found to be deficient, the basic strategies which can be formulated by the language user must be assessed. These strategies include recognition of patterns which are related to language but which are not language.

Tone patterns are used as a measure of pattern recognition which is related to speech. Musiek and Pinheiro (1985) state that the left hemisphere is analytical in function and is important to serial ordering of temporal information. Berlin and McNeil (1976) state that speech is a case of temporal sequence and temporal sequencing occurs in the left hemisphere.

Mazziota and Phelps (1985) tested a group of eight individuals using a nonverbal auditory paradigm consisting of tone sequences. They reported that individuals who used stereotyped visual imagery approaches, therefore, developed a strategy, showed increased metabolic activity in the left posterior temporal region during the listening task. Subjects who used less stereotyped strategies had diffuse right-sided activations and metabolic asymmetries.

Reivich, Alavi, Gur, and Greenberg (1985), also reported that subjects using a nonanalytic strategy for remembering the sequence of tones had higher metabolic rates in the right frontal and parietotemporal regions. The subjects who reported using an analytic approach had higher metabolic rates occurring in the left posterior superior temporal cortex.

Levels of Cognitive Functioning in Traumatic Brain Injury

Traditionally, head trauma individuals have been classified according to such categories as coma, stupor, delirium, and confusion. More recently the Glasgow Coma Scale has been implemented (Jennett and Teasdale, 1981). The purpose of the Glasgow Coma Scale is to predict mortality and morbidity. The Glasgow Coma Scale gives general descriptive categories of patient responses which can be useful during the acute care stages of traumatic brain injury.

The Ranchos Los Amigos Scale of Cognitive Levels and Expected Behavior (Hagen and Malkus, 1979) is now more commonly used to give descriptive categories of a traumatically brain injured individual's level of responses. This scale can be used to identify the levels of cognitive functioning of a traumatically brain injured patient during the entire period of rehabilitation. According to Hagen (1983), the purpose of this scale is to "assist in the identification of a patient's best level of functioning, and thereby, identify the best way of approaching the patient during the course of treatment" (p. 12).

The eight levels of cognitive functioning and behavioral responses form a hierarchy (See Appendix A) which is characteristic of the traumatically brain injured individual. Most brain injured individual s will present more behaviors at a certain level and other responses above and below that level. Determination of the level and range of cognitive/communicative behaviors provides the information of the individual's highest level of functioning.

C. STATEMENT OF THE PROBLEM

The traumatically brain injured individual's language is most often described as "confused" which is explained as "reduced recognition and responsiveness in understanding of the environment; faulty short term memory, mistaken reasoning, disorientation in time and space, and behavior which is less adaptive and appropriate than normal" (Halpern, Darley, and Brown, in Chapey, 1986, p. 475). The traumatically brain injured population is not a homogeneous group but they have been consistently described as having attentional deficits and language processing problems which could be due to an auditory processing deficit. The review of the literature suggests that further research in the area of auditory processing is needed. Pinheiro and Musiek, and Willeford have reported the most extensive studies in this area. However, empirical evidence regarding the auditory processing skills of the traumatically brain injured population is not available. This study investigated how well traumatically brain injured individuals processed auditory information by assessing their performance on tone pattern recognition tasks. The purpose of this study was to investigate the correlation between auditory processing skills and the levels of cognitive functioning in the traumatically brain injured population. A second and related purpose of this study was to determine the construct validity of a tone pattern recognition task with a traumatically brain injured population, as a measure of cognitive auditory processing.

CHAPTER II

METHODS AND PROCEDURES

A. METHODS

Introduction and Purpose

The approach used in this study was a tone pattern recognition task. The purpose of this experimental task was to assess the predictability of the tone pattern recognition task to separate cognitive levels and also to determine the construct validity of this task. The population used for this experiment was traumatically brain injured patients enrolled in an outpatient rehabilitation program.

Subjects

The methods implemented in this experimental study involved the selection of eight male subjects, ranging in age from eighteen to thirty years of age. The experimental group (four subjects) were individuals who were involved in an outpatient rehabilitation program at the Patricia Neal Rehabilitation Center, at Fort Sanders Regional Medical Center, Knoxville, Tennessee. All experimental subjects sustained their traumatic brain injury in a motor vehicle accident. All were in a coma less than one month. The experimental subjects were cognitively assessed upon admission in the rehabilitation program. The rehabilitation team periodically updated each individuals' current level of functioning as demonstrated by behaviors in a variety of environments. The cognitive level of each of the traumatically brain injured individuals in this study was their current level of functioning according to the rehabilitation team at the time of the testing. If an experimental subject had a history of previous traumatic brain injury, learning disabilities, alcohol or substance abuse, it was so noted in the case history included in the appendix for the subject (Appendix B). The control group, also consisted of four subjects, all normal males with no history of traumatic brain injury, learning disabilities, alcohol or substance abuse. All experimental subjects met the following selection criteria:

1. Diagnosed as having traumatic brain injury (closed head injury) by a physician;

2. Cognitively assessed by the rehabilitation team (physician, nursing staff, speech/language pathologist, physical therapist, psychologist, occupational therapist, recreational therapist, and social worker) by the Ranchos Los Amigos Scale of Cognitive Levels and Expected Behavior (Hagen and Malkmus, 1979) as level 6 - 8;

3. Passed hearing screening at 25 dB at 500 Hz, 1,000 Hz, 2,000 Hz, 3,000 Hz, and 4,000 Hz;

4. Is a native English speaker;

5. Demonstrated adequate upper extremity mobility for writing; and

6. Enrolled in an outpatient rehabilitation program.

Experimental Task

The experimental task used in this study was a tone pattern recognition task. This tone pattern recognition task was developed by Harold A. Peterson, Ph.D., at the University of Tennessee, Knoxville, Tennessee, as an assessment of auditory processing. The tasks on the tone pattern recognition battery are considered relatively easy for normal adults. The tasks have been administered to nine to twelve year-old children who obtained accuracy comparable to the accuracy of normal adults. This task consists of six subtests:

1. Two tones are given. The subject's task is to count the low tone. There is an 80 percent frequency of the higher tone and a 20 percent frequency of the lower tone.

2. Two pairs of tones are given. One pair of tones is different and one pair is alike. The subject indicates which pair is different.

3. Three tones are given. The subject is to indicate which one of the tones is different or if they are all the same.

4. Four tones are given. The subject is instructed to indicate which of the four is different from the other three.

5. Two tones are given. The subject is instructed to indicate if the second tone is higher or lower than the first tone or if both tones are the same.

6. Three tones are given. The subject is instructed to mark the answer sheet according to the high and low patterns of the tones.

The low tone is a 500 Hz pure tone, while the higher tone is set at 1,000 Hz. The tone pattern recognition task was programmed and generated on a Texas Instruments (TI99/4A) computer. The computer programs generated the sequence of tones according to the six tasks outlined above. A copy of the tone pattern recognition task was recorded on a video tape cassette. The sound system of the video monitor plays the tone sequence and the video shows the number of the test item to aid the listener in keeping his place on the score sheet. Since the same copy of the task on video tape was played for all subjects, homogeneity of the experiment was preserved. The subjects indicated their choices of answers on an answer sheet.

Pinheiro and Musiek (1985) state that the duration of the individual components in a sequence influences the perception of the sequence and the task of ordering it. Pinheiro and Andrews (as reported by Pinheiro and Musiek, 1985) used temporally spaced tone triplets to determine the effects of tone duration and silent interval duration on the performance of pattern recognition tasks. Tone durations were varied within the range of 150 to 500 msec while the interstimuli interval durations were varied within the range of 50 to 300 msec. These authors reported that the adult subjects achieved 100 percent accuracy on the tone pattern recognition tasks when pitch pattern components and silent intervals had durations of 150 to 200 msec with a total pattern duration of 900 msec.

The computer programs for this series of tone patterns were written in TI Basic and consisted of a sequence of random number generations and logic loops. Obviously, tone durations, inter-stimulus intervals, and between-set intervals were specified in the programs. The number and order of loops sequenced and more or fewer program lines to be scanned, however, depended on the values of the initial tones generated. The original output of the programs was stored on an FM magnetic audio cassette tape, and rerecorded to a video cassette. To determine if there was variability in the accuracy of tone durations and in inter-stimulus intervals at different locations in the test sequence, the video cassette tape was played to a Visi-Pitch. The Visi-Pitch was used to measure the duration of tones, the inter-stimulus interval, and the time interval between sets of tones for the experimental task used in this study (See Table 1).

Table 1. Measurements of Duration of Tones, Inter-stimulus Interval (ISI), and Time Interval Between Sets of Tones for Tone Pattern Recognition Tasks

	Subtest	Duration (msec)	ISI (msec)	Between Sets (msec)
1	Single tone - oddball	192-256	N/A	1840-1920
2	Four tones - two pairs	288-300	592-608	3520-3584
3	Three tones	224-256	656-688	4256-4288
4	Four tones	272-288	560-624	3472-3568
5	Two tones	304-320	592-608	4096-4192
6	Three tones	272-320	624-640	4192-4288

B. PROCEDURES

Testing Procedures

The experimental subjects were tested at the Patricia Neal Rehabilitation Center at Fort Sanders Regional Medical Center, Knoxville, Tennessee. Informed consent for the testing was obtained prior to the experimental session.

One session of approximately 45 minutes in length was spent with each subject. The testing took place in a quiet room. During the task, the investigator was seated next to the subject. A television monitor and a video cassette recorder were used to present the tone pattern recognition task. The subject was given a pencil, an answer sheet, and a writing surface to suit the need of the subject (i.e., a board for the wheelchair or a desk to sit at). Prior to playing the video tape, the investigator instructed the subject regarding the general procedures of the task: "I would like for you to listen and watch this video tape. You will hear some tones. Some will be low and some will be high. The first task will have single tones, later tasks will have two, three, or four tone sequences. The video monitor will show ten examples before each task with the tones identified as high (H) or low (L). The next 50 test items will show only the number of the item for your score sheet. There is about a minute break after each ten test items. Try to keep up, and mark your choice quickly - there is about a half minute between items. Any questions? After the ten demonstration items I will give you a chance to ask questions again." Practice items were given after the initial instructions. Ten practice items with tones identified as high or low preceded each 50 item subtest.

They were not intended to establish a criterion level, only to give familiarity with the stimuli.

The written and oral instructions on the video tape were included with the verbal instructions given by the investigator for each subtest:

1. Circle the number of the low tones.
2. Circle the pair that is different.
3. Which of the three tones is different from the other two or are all three the same?
4. Which of the four tones is different?
5. Is the second tone higher or lower than the first one? or are they both the same?
6. Mark the answer sheet with the pattern of tones.

Analysis of Data

The response sheets for each subject were scored by the investigator. The percentage correct for each subtest was determined. Since there were apparent differences in accuracy between normal subjects and the traumatically brain injured subjects, the patterns of responses were analyzed to determine what types of tasks contribute to the differences in difficulty. There were also apparent differences in accuracy and patterns of performance among the three cognitive levels as described by Hagen and Malkmus (1979) and as measured by the Ranchos Los Amigos Scale of Cognitive Levels and Expected Behavior for the experimental subjects. That finding would be assumed as partial support for the construct of using tone pattern sequences as part of the armamentaria for the measurement of cognitive processing.

CHAPTER III

RESULTS AND DISCUSSION

A. RESULTS

This was a pilot study to look at the performance of traumatically brain injured males on an auditory processing task using a tone pattern recognition task. The differences in accuracy between normal subjects and traumatically brain injured subjects were analyzed to determine what types of tasks contribute to the differences in difficulty. The differences in accuracy and patterns of performance among the three cognitive levels (Ranchos Los Amigos Scale of Cognitive Levels and Expected Behaviors, Hagen and Malkmus, 1979) 6 - 8 were analyzed to investigate a possible relation between auditory processing skills and the levels of cognitive functioning. Results were taken from the percentage correct out of 50 responses for each of six subtests comprising the tone pattern recognition tasks.

B. DATA

Differences between Normal Subjects and Traumatically Brain Injured Subjects

The performance of the subjects on the six subtests is shown in Table 2. The mean for all six subtests for each subject is also shown. Subjects numbered one through four are traumatically brain injured, while subjects numbered five through eight are normal. The mean of the performance on all subtests for the traumatically brain injured group was 92.5 percent. The mean of the performance on all subtests for the normal group was 99.75 percent.

As can be seen by the inspection of Table 2, two of the normal subjects made no errors, one subject made one error and the fourth subject made one error on each of two subtests. In other words, the pattern recognition was very easy for the normal subjects. Of the experimental subjects, one made no errors (Subject 4 with the longest post-onset time), two had moderate difficulty with the tasks, and Subject 2 apparently found the tasks quite difficult. If it

Table 2. Raw Data Concerning the Performance of the Subjects on the Six Subtests

	Percentage Correct on Each Subtest						
Subject	1	2	3	4	5	6	Mean
1	96	98	98	82	100	84	93.0
2	100	90	66	86	72	92	84.3
3	100	100	98	88	90	80	92.7
4	100	100	100	100	100	100	100.0
Mean for Traumatic Brain Injury Subjects	99.0	97.0	90.5	89.0	90.5	89.0	92.5
5	100	100	100	98	100	100	99.7
6	100	100	100	100	100	100	100.0
7	100	100	100	100	100	100	100.0
8	100	100	100	98	98	100	99.3
Mean for Normal Subjects	100.0	100.0	100.0	99.0	99.5	100.0	99.75

is assumed from the performance of the normal subjects, that one error (98 percent accuracy) is normal performance, then Subject 1 performed in the normal range on three of the six subtests, Subject 2 on only the easiest subtest (count the low tones), Subject 3 was in the normal range on three of the six subtests, and Subject 4 was in the normal range for all of the subtests. The traumatically brain injured subjects, as a group, only performed within the normal range on the first and easiest subtest. The order of difficulty of the subtests is approximately what was expected.

Post-Onset Time

The mean score and the post-onset time for the traumatically brain injured subjects is shown in Table 3. The subject (number 2) who most recently received the traumatic brain injury (3 months) obtained a mean score of 84.3 percent while the subject (number 4) who had the longest post-onset time obtained a mean score of 100.0 percent.

Table 3. Level of Cognitive Functioning, Post-Onset Time, Cognitive Rehabilitation, and Mean Score for All Subtests for Traumatically Brain Injured Group

Subject	Ranchos Los Amigos Level *	Post-Onset Time (Months)	Cognitive Rehabilitation	Mean for all Subtests
1	7	7	Yes	93.0
2	8	3	No	84.3
3	7	9	Yes	92.7
4	6	10	Yes	100.0

* Level 8 on the Ranchos Los Amigos Scale of Cognitive Levels and Expected Behavior is the highest level of functioning (See Appendix A).

Cognitive Rehabilitation

Three of the four traumatically brain injured subjects received a cognitive rehabilitation therapy provided through the Psychology Department at Fort Sanders Regional Medical Center. The three subjects who had received cognitive rehabilitation training obtained a higher mean percentage correct than the individual (subject 2) who did not receive that type of retraining (See Table 3). This subject who did not receive cognitive rehabilitation also received the most recent traumatic brain injury.

Age and Education

The age and educational history for all subjects is shown in Table 4. Neither age nor education seemed to influence scores for either the traumatically brain injured group or the normal group. In the traumatic brain injury group, one of the high school educated subjects obtained the highest score (100 percent) and the other high school graduate scored the lowest (84.3 percent). Among the normal group subjects, one of the high school graduates scored 100 percent, as did the college graduate, and the other two had scores of 99.7 percent and 99.3 percent (one error in six subtests, and two errors in the six subtests, respectively).

Table 4. Age, Educational History, and Mean Score for Traumatically Brain Injured and Normal Subjects

Subject	Age	Education Completed	Average Score for all Subjects
1	18 - 9	11th grade	93.0
2	28 - 3	high school	84.3
3	29 - 4	11th grade	92.7
4	22 - 10	high school	99.7
5	19 - 4	high school	100.0
6	23 - 10	college	100.0
7	18 - 9	high school	100.0
8	18 - 10	high school	99.3

Error Patterns

The mean score for each subtest for all subjects is shown in Table 2. The mean score of the traumatically brain injured subjects is lower than the mean score of the normal subjects for all six subtests. The traumatically brain injured subjects exhibited less difficulty on the first subtest ("Circle the low tone"). The subtests of greater difficulty for the traumatically brain injured group were the fourth subtest ("Which of the four tones is different?")

and the sixth subtest ("Mark the pattern of the tones"). A pattern of performance did not appear to differ among the three cognitive levels of traumatically brain injured subjects in this study.

The data does not indicate that the subjects exhibited a fatigue factor for the test as a whole. Traumatically brain injured subjects did appear to exhibit a fatigue factor within subtest but this appears to be primarily due to performance on subtest 4 (See Table 5). These subjects made more errors on items forty-one through fifty for each subtest. The normal subjects did not exhibit a fatigue factor within the subtests.

Table 5. Fatigue Factor for the Traumatically Brain Injured Subjects

Sub-test	Errors on Numbers: 1-10	11-20	21-30	31-40	41-50
1	0	2	0	0	0
2	1	3	1	1	0
3	4	4	1	6	4
4	2	2	0	4	14
5	5	2	2	6	4
6	4	4	2	5	6
Total	16	16	8	15	28

Levels of Cognitive Functioning

The levels of cognitive functioning and the mean score for all subtests is shown in Table 3 (See Appendix A for an explanation of the cognitive levels). Subject number 4, who was at Ranchos Los Amigos level 6, obtained the highest mean score of the traumatic brain injury group with a mean score of 100.0 percent. Subjects number 1 and 3, who were at level 7, received mean scores of 93.0 percent and 92.7 percent, respectively. Subject number 2, who was at level 8 (the highest performance on this scale), received a mean score of 84.3.

C. DISCUSSION

The results of this pilot study suggest that there is a difference in the accuracy between normal subjects and the traumatically brain injured subjects. The differences in accuracy and patterns of performance do not appear to be related to the cognitive levels as measured by the Ranchos Los Amigos Scale of Cognitive Levels and Expected Behavior (Hagen and Malkmus, 1979).

Difference in Performance of Traumatically Brain Injured Subjects and Normal Subjects

Three of the four traumatically brain injured adults included in this study exhibited more difficulty on a tone pattern recognition task than normal adults. The one who had the longest time since traumatic onset performed like the normal controls, but interestingly, was at a lower Ranchos Los Amigos level of functioning than the subjects who performed less well on tone pattern recognition.

Without the investigator's initiation, all four normal subjects reported using a strategy during the tone pattern recognition tasks. Only one of the traumatically brain injured subjects (subject number 4, who had a perfect score) was observed using a possible strategy (i.e., tapping his foot to the rhythm of the tones). None of the other traumatically brain injured subjects reported nor were they observed using a strategy during the tone pattern recognition tasks.

During the testing procedure, no additional comments or instructions from the investigator other than the instructions on the video tape were needed by the normal subjects. Three of the four traumatically brain injured subjects needed extensive to moderate additional instruction. Subject 1 needed extensive instruction to comprehend the directions for each subtest. He was observed to lose his place and his attention occasionally wandered. The investigator only provided minimal cues to keep him on task and to finish the testing procedure. Subjects 2 and 3 required moderate instruction from the investigator. It was necessary for the investigator to paraphrase the instructions after the initial instructions were played on the video tape. Subject 4 required no additional comments after the initial instructions on the video tape.

Difference in Accuracy and Patterns of Performance Among Cognitive Levels

The findings of this study suggest that there were not differences in accuracy and patterns of performance among the three cognitive levels used in this study. A possible explanation for the lack of difference would be a limited sample size. The sample size for this study is not a random sampling of subjects who would meet the specified criteria. They were all of the subjects available at the time.

Limitations of the Study

Sample size is an obvious limitation of this study. Due to the small sample size, statistical tests could not be performed, and, therefore, the results can only be viewed as tendencies that may warrant further study. The limited number of traumatically brain injured individuals who met the criteria and who were enrolled in the facility used for this study prevented the used of a larger sample. Since the sample size was limited, the difference in accuracy and patterns of performance among cognitive levels could not be as closely examined.

Implications for Future Research

From the results of this study, it was determined that future research is needed to more thoroughly investigate the performance of the traumatically brain injured adult on tone pattern recognition tasks. Specifically, the following areas warrant study:

1. Replication of this study involving a larger sample size of traumatically brain injured adults; and

2. Investigation of the performance of traumatically brain injured individuals, separated into experimental groups classified by site of injury, on tone pattern recognition tasks.

CHAPTER IV

SUMMARY AND CONCLUSIONS

A. SUMMARY

The purpose of this study was to determine whether or not differences exist in the accuracy of performance between normal adults and traumatically brain injured adults on tone pattern recognition tasks. A second purpose was to determine if differences exist in accuracy and pattern of performance among three cognitive levels. Each subject listened to an audio tape presentation of two, three, and four tone sequences. A video monitor showed the item number for the tone sequences to aid the listener in marking the correct item on the answer sheet.

B. CONCLUSIONS

The present study suggests that traumatically brain injured adults exhibit more difficulty on tone pattern recognition tasks than normal adults. This difference in accuracy may have been partly due to application of a strategy. In comparing the three cognitive levels, no apparent difference was found. Further research is needed before an assumption can be made as support for the construct of using tone pattern sequences as a diagnostic measure in the assessment auditory processing deficits in the traumatically brain injured population.

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APPENDICES

APPENDIX A

RANCHOS LOS AMIGOS SCALE OF COGNITIVE LEVELS AND EXPECTED BEHAVIOR

(Hagen and Malkmus, 1979)

Level I	No Response	Unresponsive to all stimuli.
Level II	Generalized Response	Inconsistent, nonpurposeful, non-specific reactions to stimuli. Responds to pain, but response may be delayed.
Level III	Localized Response	Inconsistent reaction directly related to type of stimulus presented. Responds to some commands. May respond to discomfort.
Level IV	Confused, Agitated Response	Disoriented and unaware of present events with frequent bizarre and inappropriate behavior. Attention span is short and ability to process information is impaired.
Level V	Confused Inappropriate Nonagitated Response	Nonpurposeful random or fragmented responses when task complexity exceeds abilities. Patient appears alert and responds to simple commands. Performs previously learned tasks but is unable to learn new ones.
Level VI	Confused, Appropriate Response	Behavior is goal-directed. Responses are appropriate to the situation with incorrect responses due to memory difficulties.
Level VII	Automatic, Appropriate Response	Correct routine responses which are robotlike. Appears oriented to setting, but insight, judgement, and problem-solving are poor.

Level VIII	Purposeful, Appropriate Response	Correct responding, carryover of new learning. No required supervision, poor tolerance for stress, and some abstract reasoning difficulties.

APPENDIX B

SUBJECT HISTORY

Subject 1

Age: 18 - 9

Education: completed 11th grade

Occupational status: student

Marital status: single

Participated in cognitive rehabilitation program

Behavior during testing procedure: This subject needed extensive instruction to comprehend directions for each subtest. His attention wandered and he lost his place a few times

Subject 2

Age: 28 -3

Education: completed high school

Occupational status: policeman

Marital status: married

Did not participate on cognitive rehabilitation program because it was judged by the Psychology Department that "he did not need to".

Behavior during testing procedure: This subject required moderate paraphrased instructions from the investigator.

Subject 3

Age: 29 - 4

Education: completed 11th grade

Occupational status: held various jobs

Marital status: married

Participated in cognitive rehabilitation program

Behavior during testing procedure: This subject required moderate paraphrased instruction from the investigator

Subject 4

Age: 22 - 10

Education: completed high school

Occupational status: worked at family business

Marital status: single

Participated in cognitive rehabilitation program

Behavior during testing procedure: This subject refused additional instructions from the investigator.

Subject 5

Age: 19 - 4

Education: completed high school, currently a sophomore in college

Occupational status: student

Marital status: single

Behavior during testing procedure: This subject did not require any additional instructions from the investigator.

Subject 6

Age: 23 - 10

Education: completed Bachelor's degree, currently in graduate school

Occupational status: teacher

Marital status: single

Behavior during testing procedure: This subject did not require any additional instructions from the investigator.

Subject 7

Age: 18 -9

Education: completed high school, currently a sophomore in college

Occupational status: student

Marital status: single

Behavior during testing procedure: This subject did not require any additional instructions from the investigator.

Subject 8

Age: 18 - 10

Education: completed high school, currently a sophomore in college

Marital status: single

Behavior during testing procedure: This subject did not require any additional instructions from the investigator.

VITA

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