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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

A NEUROPSYCHOLOGICAL EXAMINATION OF COGNITIVE AND PERCEPTUAL CAPACITIES IN CHRONIC ALCOHOLICS

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A NEUROPSYCHOLOGICAL EXAMINATION OF COGNITIVE AND PERCEPTUAL CAPACITIES IN CHRONIC ALCOHOLICS

APPROVED BY

DISSERTATION COMMITTEE

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And finally to my Mother, who always claimed that an education was worth something, this dissertation is dedicated to, from her son the doctor. As was so cogently stated by Erasmus (1466-1536) many years ago:

I must acquire the absurd title of "Doctor."
It will not make me a hair the better
but as time goes, no man can be counted learned
unless he is styled "Doctor."
If the world is to believe in me,
I must put on the lion's skin.
I have to fight with monsters and
I must wear the dress of Hercules.

TABLE OF CONTENTS

Page

LIST OF TABLES vi

LIST OF ILLUSTRATIONS viii

Chapter

I. INTRODUCTION AND LITERATURE REVIEW 1

II. STATEMENT OF THE PROBLEM 26

III. EXPERIMENT I: INTER- AND INTRA-PROBLEM PERFORMANCE OF ALCOHOLICS ON A CONCEPT IDENTIFICATION TASK 31

IV. EXPERIMENT II: SET SHIFTING CAPACITY OF CHRONIC ALCOHOLICS 58

V. EXPERIMENT III: NEUROPSYCHOLOGICAL CONCOMITANTS OF CHRONIC ALCOHOLISM 80

VI. GENERAL DISCUSSION 101

VII. SUMMARY 123

REFERENCES 127

APPENDIX 137

LIST OF TABLES

Table		Page
1.	Means and Standard Deviations for Age, Education, Shipley-Hartford Scores and WAIS Equivalent IQ	34
2.	Summary of Analyses of Variance on Each Measure	40
3.	Mean Scores for Each Group on Perseverative and 'Other' Errors	43
4.	Summary of Analysis of Variance on Percent Errors	44
5.	Means and Standard Deviations for the Percent of Interruptions Per Set for Each Group	50
6.	Means and Standard Deviations for Percent of Times Per Set That An Error Sequence of Five or More Consecutive Incorrect Responses was Committed by Each Group	51
7.	Means and Standard Deviations for Trials and Total Errors on the First Set	54
8.	Means and Standard Deviations for Age, Education, Shipley-Hartford Scores and WAIS Equivalent IQ	61
9.	Mean Scores for Each Group on the Measures of Perseverative Errors, 'Other' Errors and Perseverative Errors Emitted within the First 10 Trials After a Set Shift	67
10.	Summary of Analyses of Variance Between All Three Groups for Each Measure on Sets 1-7	68
11.	Summary of Analyses of Variance Between All Three Groups for Each Measure on Sets 8-10	69
12.	Summary of Analyses of Variance Between the Controls and the Combined Group of Alcoholics on Each Measure for Sets 1-7	71
13.	Summary of Analyses of Variance Between the Controls and the Combined Group of Alcoholics on Each Measure for Sets 8-10	72
14.	Summary of Analysis of Variance on Spatial Perseverations	73
15.	Means and Standard Deviations of Rate of Responding (Card Sorts Per Minute) for Each Group	74

LIST OF TABLES--Continued

Table		Page
16.	Means and Standard Deviations for Each Group on the Maze Tracing Speed Test	86
17.	Means and Standard Deviations for the Fourteen Long-Term Alcoholics on the Maze Tracing Speed Test	86
18.	Means and Standard Deviations for the Three Groups on the Time Measure of the Goal Directed Serial Alternation Test	88
19.	Means and Standard Deviations on the Number of Arithmetic Errors, and the Number of Subjects in Each Group Who Committed One or More Such Errors on the Goal Directed Serial Alternation Test	89
20.	Frequency of Times and Number of Subjects in Each Group Who Committed An Alternation Error	90
21.	Frequency of Times and Number of Subjects within Each Group for Whom a Loss of Place Occurred on the Goal Directed Serial Alternation Test	91
22.	Means and Standard Deviations for Each Group on the Copying Test	92
23.	Correlations Between the Total Number of Boxes Completed on the Maze Tracing Speed Test and the Trials and Errors Measures of the Wisconsin Card Sorting Test	94
24.	Correlations Between the Total Percent Correct Answers on the Copying Test and the Trials and Errors Measures of the Wisconsin Card Sorting Test	95
25.	Correlations Between the Total Time Scores on the Goal Directed Serial Alternation Test and the Trials and Errors Measures of the Wisconsin Card Sorting Test	97
26.	Intercorrelations Between the Goal Directed Serial Alternation Test, Copying Test and Maze Tracing Speed Test for Each Group	98
27.	Performance of Short- and Long-Term Alcoholics on the Clinical and Selected Personality Scales of the MMPI	119

LIST OF ILLUSTRATIONS

Figure		Page
1.	Mean Trials to Criterion on Each Cycle for the Controls, Short- and Long-Term Alcoholics	41
2.	Mean Total Errors on Each Cycle for the Controls, Short- and Long-Term Alcoholics	42
3.	Mean Perseverative Errors Emitted within the First Ten Trials After a Set Shift on Each Cycle for the Controls, Short- and Long-Term Alcoholics	45
4.	"Learning to Learn" Curves for the Controls, Short- and Long-Term Alcoholics	47
5.	Percentage of Times that an Error Succeeded a Sequence of Consecutive Correct Responses	48
6.	Percentage of Times that an Error Succeeded a Sequence of Consecutive Incorrect Responses	52
7.	Mean Trials to Criterion	65
8.	Mean Total Errors	66

A NEUROPSYCHOLOGICAL EXAMINATION OF COGNITIVE AND PERCEPTUAL CAPACITIES IN CHRONIC ALCOHOLICS

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

The psychological consequences of chronic alcohol abuse has not been systematically investigated until recently. Compared to the volume of research that has been conducted with patients suffering from the Wernicke-Korsakoff Syndrome, a disease most frequently the result of a long standing history of alcoholism, there is conspicuously little known about the intactness of psychological functioning in chronic alcoholics. For example, two investigators (Meissner, 1967; Talland, 1965) have comprehensively evaluated the nature and extent of impairment in Wernicke-Korsakoff patients, but no such analysis has yet been attempted with chronic alcoholics.

There are at least three reasons why the psychological concomitants of chronic alcoholism merit investigation. First, it is of importance to know for nosological reasons if the behavioral deficits observed in clinically diagnosed Korsakoff patients are also present in the less severely deteriorated alcoholic. There is some indication that at least for some capacities this may be the case. Malerstein (1969) demonstrated that alcoholics and Korsakoff subjects both exhibited a lack of initiative

in resuming an interrupted task, while Tarter and Parsons (1971) found that alcoholics were impaired at task persistence, two characteristics previously thought by Talland (1965) to be specific to the Korsakoff Syndrome. Thus certain deficits that have been identified in Korsakoff patients have also been shown to be present in chronic alcoholics.

A second reason for studying chronic alcoholics is that it enables the systematic evaluation of the status of psychological functions in relation to the duration of alcoholism history. Since the disruption of capacities is undoubtedly not an all-or-none phenomenon, but is progressive, and a function of the history of alcohol abuse, it can be determined in the alcoholic the point at which the deficits become manifest. Furthermore, the prognosis for recovery of function with respect to the individual's alcoholism history can be established. Hence, Tarter and Parsons (1971) observed that the propensity for interrupting a correct sequence of responses in an abstracting task was directly related to drinking history. In another experiment Tarter and Jones (1971a) it was found that muscle strength and motor speed declined as the duration of alcoholism history increased. In addition, it was demonstrated in the latter investigation that the prognosis for recovery decreased with increasing duration of alcoholism history. Therefore by investigating the chronic alcoholic, it can be determined at which point in relation to the individual's history of alcohol abuse an impairment in a given psychological capacity becomes manifest, so that the prognosis for recovery of that function can be established.

And thirdly, by providing a comprehensive analysis of the level of psychological functioning, the most suitable form of treatment can be

implemented. Hence, Kissen, Platz and Su (1970) were able to demonstrate that the more psychologically competent alcoholic responded best to a psychotherapy form of treatment while the less adept profited best from a treatment procedure which emphasized drug therapy.

Thus investigations into the psychological consequences of chronic alcohol abuse have many ramifications. The similarities and differences between chronic alcoholics and Korsakoff psychotics remain to be delineated. The relationship between drinking history, psychological competence, and prognosis for recovery also still needs to be elucidated. And finally, the mode of treatment can be more accurately selected once the level of functioning is comprehensively assessed.

The remainder of this chapter will review the literature pertaining to intellectual, perceptual, memorial and cognitive capacities and will be concluded with a discussion examining the neuropsychological evidence for a central nervous system impairment in chronic alcoholics.

Intellectual Competence

The evidence is virtually unanimous in rejecting the notion that chronic alcoholics suffer from a generalized or global intellectual deterioration. Kish (1970) and Tarter and Jones (1971b) demonstrated that the conceptual quotient (CQ), an index of intellectual deterioration, was not different from that of either psychiatric patients or normal controls. In the latter study (Tarter and Jones, 1971b), it was further demonstrated that no significant association existed between CQ and number of years the person had been drinking alcohol or between CQ and the number of years the person described himself as an alcoholic.

Investigations with the Wechsler Adult Intelligence Scale (WAIS)

and Wechsler-Bellvue Intelligence Scale (W-B) substantiate the findings of intact intellectual functioning. Alcoholics performed in the average (Bauer and Johnson, 1957; Fitzhugh, Fitzhugh and Reitan, 1960, 1965; Peters, 1956; and Wechsler, 1941, 1958) to superior ranges of intellectual functioning (Halpern, 1946; Kaldegg, 1956; Malerstein and Belden, 1968; and Plumeau, Machover and Puzzo, 1960). In one report (Kaldegg, 1956), fifty percent of the alcoholics obtained an IQ greater than 120. Murphy (1953) administered the Wechsler-Bellevue to a group of middle and lower class alcoholics and found that the middle class alcoholics obtained a mean full scale IQ of 123, while the lower class alcoholics achieved a mean IQ of 109.

Comparison of the verbal and performance IQ's of alcoholics reveals a surprisingly consistent result. With the exception of the two reports by Fitzhugh et al. (1960, 1965), all of the investigations cited above found a small but consistent superiority of the verbal over the performance IQ. Teicher and Singer (1946) although not presenting their data, concluded that alcoholics have a reduced performance IQ relative to their verbal IQ. This difference in subscale IQ's appears too consistently in the literature to be attributed to chance, and is large enough so as to reflect more than what would ordinarily be expected if it were a result of the normal aging process alone (Wechsler, 1941).

Roe and Shakow (1944) found that patients in a state of acute alcoholic psychosis and patients diagnosed as chronic alcoholic with psychosis achieved a lower mental age score on the Stanford-Binet than a group of normals. Interpretation of their results however is difficult since the effects of the psychosis alone could account for these find-

ings.

Alcoholics have been demonstrated to manifest an impairment on the Raven's Progressive Matrices (Jones and Parsons, 1970). This test has previously been shown to load on the factors of general intelligence and perceptual organization (Burke and Bingham, 1969). Bauer and Johnson (1957) administered the 1938 version of the test and found no differences between alcoholics and controls, but the inclusion of psychotics in the control group obscure their results. Further research is necessary before a conclusion can be drawn as to how alcoholics perform on this test. It then remains to be determined if an impairment is manifested, whether it is due to an intellectual loss per se, or attributable to a more specific deficit in perceptual organization capacity.

The General Aptitude Test Battery has also been administered to chronic alcoholics but without striking results (Kish, 1970; Kish and Cheney, 1969). Alcoholics evidenced impairment on the Numerical, Motor coordination, Finger dexterity and Manual dexterity aptitudes. General Intelligence and the Verbal, Spatial, Perceptual and Clerical aptitudes were intact. Thus the only cognitive test in which the alcoholics exhibited an impairment was the Numerical aptitude, the remaining tests tap primarily motor capacities. The reason for the impairment on the Numerical subtest is, however, unclear.

The Halstead-Reitan battery has been shown to be a valid indicator of "biological intelligence" (Halstead, 1947). As such, its value has been proven in its capacity to identify central nervous system dysfunction (Reitan, 1955; Vega and Parsons, 1967). Fitzhugh et al. (1960, 1965) and Goldstein and Shelly (1971) administered this battery and found

that the alcoholics exhibited evidence of a neurological impairment. Thus while psychometric intelligence is intact in chronic alcoholics, there is a notable decrement in biological intelligence. Neither psychometric (Plumeau, Machover and Puzzo, 1960) nor biological intelligence (Goldstein, 1970) is however related to therapeutic outcome of treatment.

In conclusion, it appears that alcoholics do not suffer from a generalized deterioration of all intellectual capacities as measured by standardized intelligence tests. On the WAIS and Wechsler-Bellvue, a slight but consistent superiority of the verbal IQ relative to the performance IQ is typically observed. There is some suggestive evidence that alcoholics are impaired on the Raven's Progressive Matrices, a test which measures both general intelligence and perceptual organization, but more research is necessary before a definite conclusion can be reached as to the actual cause of the deficit. With the exception of the Numerical aptitude, alcoholics perform competently on all of the cognitive tests of the General Aptitude Test Battery. Alcoholics exhibit an impairment in biological intelligence as measured by their performance on the Halstead-Reitan Battery. Prognosis of treatment outcome does not appear to be related to either "biological" or "psychological" intelligence.

Perceptual Speed

Alcoholics do not manifest any striking deficits in the area of perceptual speed. Claeson and Carlsson (1970) administered the Figure Identification Test and found that their twenty alcoholics obtained a mean stanine score of five as compared to the theoretically expected

score of between six and seven. The significance of this finding is obscure however as no inferential statistics were calculated. On this test the subject is first shown a picture and then must pick it out as quickly as possible from five alternatives.

Goldstein and Chotlos (1965) administered the Stroop Test and found intact performance on the word-naming part but lowered performance efficiency on the color-naming and interference parts of the test. When the effects of the color were partialled out on the interference task, no deficit was manifested, suggesting that the performance decrement was limited only to the color characteristics of the task.

Alcoholics do not manifest an impairment on the Street Gestalt Test, a test which loads primarily on a "speed of perception" factor and to lesser extent on the factor of "speed and strength of closure" (Thurstone, 1944). On this test the subject must identify a picture which is presented in fragmented form on a card. Claeson and Carlsson (1970) administered the Street Gestalt Test to a group of alcoholics and observed that they obtained a mean stanine score of six as compared to the expected score of between six and seven from the general population.

In summary, it does not appear that alcoholics suffer from an impairment in perceptual speed. The one exception to this conclusion is indicated by the relatively inferior performance of alcoholics on the color-naming part of the Stroop Test. The reason for this is not understood, but may reflect a physiological defect in color vision as has been reported by Sassoon, Wise and Watson (1970).

Perceptual-Motor Coordination

The Bender-Gestalt Test has long been used to assess visuomotor coordination. Bender (1938) administered this test to a group of patients diagnosed as chronic alcoholics with psychosis. She found that the reproductions of the designs by the alcoholics were not well integrated and indicated an impairment in synthetic spatial ability. No visual impairment was noted, rather the deficit was one of organizing their reproductions into the proper perspective.

Other investigators have not observed an impairment in chronic alcoholics on the Bender-Gestalt Test (Hirschenfang, Silber and Benton, 1967, 1968; Kates and Schmolke, 1953; and Silber, Hirschenfang and Benton, 1968). In one investigation (Reinehr and Golightly, 1968), it was found that only three of thirty subjects performed in the critical or impaired range of functioning while seven subjects performed in the borderline range. Kaldegg (1956) reported that eleven of eighteen alcoholic subjects exhibited some indication of impairment.

Though the findings to date are not conclusive and somewhat contradictory, they suggest that when an impairment is manifested it has only a moderate debilitating effect. Even so, not all investigators have shown that alcoholic subjects do indeed manifest a deficit on this task.

Spatial Ability

There are undoubtedly many different aptitudes which are subsumed under the general designation of spatial ability. For example, Guilford (1967) has identified thirty figural or spatial factors. Therefore, depending on the specific test employed, only certain aspects of an overall spatial ability are measured by that particular instrument.

For organizational purposes, this author has divided this capacity into four categories. They are:

1. Spatial synthesis. Tasks that are sensitive to measuring this capacity have the features of requiring the subject to either create Gestalts from elements or to reproduce patterns or designs from a model (e.g., Kohs Block Design Test).

2. Spatial orientation. Tests that tap this capacity require the subject to make judgments of the properties of stimulus objects in a field under varying conditions of bodily orientation (e.g., the rod and frame test) or to identify and classify figures which are in varying positions of rotation (e.g., Figure Classification Test).

3. Spatial flexibility or closure. These tests require the subject to discover a relatively simple figure that is embedded or "hidden" in a complex field (e.g., Gottschaldt or Embedded Figures Test).

4. Spatial scanning. Tasks that require the subject to execute a specific sequence of responses in a simple or complex visual field measure this capacity (e.g., mazes and Trail Making Test).

These four categories of spatial functioning are not implied or intended to be independent of each other. They are grouped here on the basis of the face validity of the particular test, and only for convenience so as to facilitate the identification and description of the behavioral deficits.

Spatial Synthesis

The most frequently employed instrument has been Kohs Block Design Test, or a variant of it, the Wechsler-Bellevue and WAIS Block Design Test. Fitzhugh *et al.* (1965) found that alcoholics performed

significantly more poorly than controls on only this subtest of the Wechsler-Bellevue. Goldstein, Neuringer and Klappersack (1970) observed that alcoholics were impaired on the WAIS Block Design Test. Grassi (1953) reported a "moderate" impairment on the Grassi Block Substitution Test in deteriorated alcoholics. Jonsson, Cronholm and Izikowitz (1962) also observed that alcoholics were deficient on this task. Gordan (1957) found that alcoholics did not perform more poorly on the "abstract" than "concrete" items on the Grassi Block Substitution Test. Claeson and Carlsson (1970) observed that their chronic alcoholics obtained a mean stanine transformed score of five on the Kohs Block Design Test where the theoretical expectation was between six and seven. Unfortunately, no inferential statistics were calculated to evaluate the significance of this observation.

Fitzhugh et al. (1960) found that alcoholics were inferior to controls on the time measure of the Tactual Performance Test of the Halstead-Reitan Battery. Adding another eighteen subjects to the alcoholic group (Fitzhugh et al., 1965), they observed that the alcoholics performed more poorly than controls on the locations in addition to the time measure of this test. These results suggest that alcoholics suffer from a spatial deficit that is not dependent on visual information processing since the Tactual Performance Test is conducted while the subject is blindfolded. The impaired performance on the locations measure indicates that alcoholics are unable to organize or conceptualize the elements of the "field" into their proper perspective. This is suggested by the observation that they made more errors than controls when asked to describe the position of the geometric figures or objects in the form

board. Also of interest is the finding that the alcoholics did not differ from the controls on the memory measure, illustrating that the spatial deficit on this task cannot be attributed to an impairment of memory.

In summary, it appears that alcoholics are impaired at tasks that require synthesis of a pattern from its elements as indicated by their performance on the various block design tests. This deficit in spatial ability is not necessarily due to an impaired capacity of visualization since alcoholics are also deficient on the Halstead-Reitan Tactual Performance Test which is performed while blindfolded.

Spatial Orientation

No area of investigation pertaining to the mode of perceptual functioning in alcoholics has received as much attention as spatial or field orientation. The instrument that has been typically employed to measure this dimension of spatial functioning is the Rod and Frame Test. In this task the subject is seated in a totally darkened room so as to eliminate all cues from the environment. The subject is then instructed to adjust a luminous rod to its true vertical position. This is done while the body is in one of three positions: upright, 28° tilt to the left, and 28° tilt to the right. In addition, a square luminous frame in various orientations surrounds the rod. The closer the subject approximates the true vertical, the better is his performance.

Witkin and coworkers (Witkin, Lewis, Hertzman, Machover, Meissner and Wapner, 1954; Witkin, Dyk, Faterson, Goodenough and Karp, 1962) have been able to describe individuals along a continuum according to their competency in performing this task. At one extreme there were those who

could accurately adjust the rod to its vertical despite the distractions and were defined as field-independent; while at the other extreme there were those who were unable to do so and were labelled field-dependent. The distinguishing feature therefore, between the field-independent and field-dependent individual is that the former can make the correct adjustment despite the distractions while the latter rely on the misleading cues from the frame and body. Field-independent subjects are thus "analytical" in their mode of perception while the field-dependent subjects are "global" in their mode of perception (Witkin et al., 1962).

Male alcoholics have been demonstrated to be markedly field-dependent (Bailey, Hustmyer and Kristofferson, 1961; Goldstein and Chotlos, 1965; Witkin, Dyk, Faterson, Goodenough and Karp, 1962, and Witkin, Karp and Goodenough, 1959). Female alcoholics have also been reported to be field-dependent (Karp, Poster and Goodman, 1963). The duration of drinking history was not found to be associated with the severity of field-dependency (Karp and Konstadt, 1965). The achievement and maintenance of sobriety did not result in any appreciable change in field orientation (Bailey et al., 1961; Karp, Witkin and Goodenough, 1965a), nor did the administration of alcohol to alcoholics (Karp, Witkin and Goodenough, 1965b). It thus appears that the field-dependent mode of perception is a pervasive and enduring trait of chronic alcoholics.

The stability of the field-dependency has however recently been challenged. In contrast to the results obtained by Bailey et al. (1961) and Karp et al. (1965a), Goldstein and Chotlos (1966) found that alcoholics improved, that is, became more field-independent after a period of abstinence from alcohol for 8-10 weeks. Jacobson, Pisani and Berenbaum

(1970) attempted to replicate Goldstein and Chotlos' (1966) results but were unable to do so, suggesting that sobriety alone was not a factor in enabling a change toward field-independency. Thus four different laboratories have been engaged in delineating the temporal stability of field-dependency in alcoholics, and only one (Goldstein and Chotlos, 1966) has reported a significant change after a period of sobriety.

The field-dependent mode of perception in alcoholics is however capable of manipulation. Jacobson (1968) found that alcoholics shifted in the direction of field-independency after a one-hour interval of sensory isolation. Subjects who did not experience the period of isolation manifested no change from test to retest. Jacobson (1968) interpreted the results by suggesting that the period of isolation enabled the subject to focus attention on internal bodily cues and sensations (kinesthetic, labyrinthine, etc.) and subsequently make them more available during conditions of bodily tilt so as to facilitate judgments of verticality of the rod.

Where perceptual judgments are required in which only the orientation of the stimulus is varied, alcoholics still manifest an impairment. Employing Thurstone's (1938) Figure Turning Test, Claeson and Carlsson (1970) found that the mean stanine score was between four and five. Fourteen of twenty subjects obtained a score of less than five. In this test the subject must identify one of seven geometric figures that would be identical to the sample figure upon orientation. In another investigation (Goldstein and Chotlos, 1965), the performance of alcoholic subjects was found to be markedly impaired at adjusting the rod while the body was in the upright position, suggesting that the poor

performance found in the usual rod-and-frame procedure was not due only to an incapacitating effect of bodily tilt. Thus alcoholics also exhibit deficits on tasks that require orientation of stimuli while the body is in an upright position.

That alcoholics perform in a field-dependent manner on the rod and frame test appears to be reliable and consistent finding. Apart from patients with known brain lesions, alcoholics tend to be more field-dependent than any other psychopathological group (Elliott, 1961). Between 75-80 percent of the alcoholics were field-dependent in the sample investigated by Bailey et al. (1961) while Witkin et al. (1959) reported that 75 percent of their alcoholic sample were field-dependent.

Flexibility of Closure

A test which correlates with the rod and frame test is the Gottschaldt or Embedded Figures Test (Witkin et al., 1962). This test was demonstrated by Thurstone (1944) to load on the factors of speed and strength of perceptual closure, and secondarily, on a factor which taps ones ability to perform under changing Gestalts. Closure was defined by Thurstone (1951) as "the ability to keep in mind a definite configuration so as to identify it in spite of perceptual distraction."

Claeson and Carlsson (1970) observed that on a stanine scale, alcoholics obtained a mean of between five and six. It does not appear from their data that the alcoholics were impaired. Eleven of twenty subjects obtained scores equal to or better than the average expected score in the population. The Embedded Figures Test as employed by Witkin et al. (1962) and later revised by Jackson (1956) has not been successful in discriminating alcoholics from non-alcoholics. Goldstein et al. (1970)

observed that a history of alcoholism was not related to performance competency on this test. In another study (Burdick, 1969) it was noted that alcoholics tended to be field-independent. Rhodes, Carr and Jurji (1968) found that their alcoholic sample did not significantly differ from normal controls on the Embedded Figures Test. Reilly and Sugerman (1967) administered this test to a group of alcoholics and found that "concrete" alcoholics were more dependent than alcoholics who function at a more abstract level. The mean for the whole group however did not suggest that they were excessively field-dependent. Jones and Parsons (1970) similarly observed no differences between alcoholics and controls on the Embedded Figures Test.

Performance on the Embedded Figures Test has been demonstrated to be significantly correlated with the rod and frame test. Witkin et al. (1962) reported that for males, the correlations ranged from + 0.36 to + 0.64 depending on the particular sample being measured. Rudin and Stagner (1958) obtained a correlation of + 0.55 between the two tests, and more recently, Goldstein et al. (1970) reported a correlation of + 0.63. These findings suggest that though the two instruments partially tap the same capacities, there is still enough residual variance to indicate that there are other uncorrelated factors that each test is measuring. An obvious conclusion to be drawn from the above discussion is that even though the tests significantly correlate with each other, it does not justify the use of them interchangeably under the assumption that both are measuring exclusively the same capacity or factor.

To buttress the conclusions that the two tests have differing as well as similar properties, it has been shown that the performance of

alcoholics on the Embedded Figures Test improved with practice (Karp et al., 1965a), while on the other hand no such improvement has been noted on the rod and frame test (Jacobson, 1968; Jacobson et al., 1970). The administration of acute dosages of alcohol to alcoholics (Karp et al., 1965b) disrupted Embedded Figures Test performance but not the rod and frame test, suggesting again that the latter test is a more stable measuring instrument.

Thus it appears that the capacity of flexibility of closure or field-dependency does not distinguish alcoholics from non-alcoholics as measured by the Gottschaldt or Embedded Figures Test. Also of importance is the conclusion that the rod and frame and Embedded Figures Tests differ enough so as to argue against their use interchangeably.

The dimension of field-dependency-independency is related to other capacities. Witkin et al. (1962) found that the perceptual index (a composite score based on the Embedded Figures, Rod and Frame and Body Adjustment Tests) correlated very highly with the performance subtests of the Wechsler Adult Intelligence Scale. Upon factor analysis it was discovered that both the perceptual index and performance subtests loaded on a spatial factor. More recently Goldstein et al. (1970) obtained significantly high correlations in alcoholics between the Embedded Figures Test and Picture Completion, Object Assembly and Block Design subtests of the WAIS, suggesting again that a spatial type of factor is measured by each of these tests.

Spatial Scanning

Some evidence has been accrued which demonstrate that alcoholics exhibit a performance decrement on tasks that require the visual guiding

of a sequence of responses through a complex visual array. Fitzhugh et al. (1960) in their first study found that the difference between alcoholics and controls approached but did not reach significance on the Trail Making Test. In a subsequent report (Fitzhugh et al., 1965) the differences between the groups were found to be significant. Goldstein and Chotlos (1965) replicated this finding and observed that alcoholics were inferior to controls on the time but not the error scores of the Trail Making Test.

On maze tests, alcoholics were found to manifest a transient deficit which disappeared after a period of abstinence (Jonsson et al., 1962). On the Levers Test, a paper and pencil test in which the subject must indicate the direction of levers that are set in motion, no differences between alcoholics and controls were observed, indicating that the performance decrement observed on the Trails Test at least cannot be attributed to an impairment of directional sense.

Learning and Memory

There are a paucity of experiments that have attempted to evaluate memory functions in alcoholics. Of the few pertinent studies, no consistent memory impairment has been noted. Jonsson et al. (1962) found that alcoholics were significantly impaired at remembering a display of common objects, but performed as well as normals in a paired associate task and another memory task in which the subject had to remember an association between a common object and a letter of the alphabet. May, Urquhart and Watts (1970) observed no evidence for an impairment of memory on the Memory-For-Designs Test. Claeson and Carlsson (1970) administered the Benton Visual Retention Test and a paired associate test

to their alcoholic subjects. They found that thirteen of twenty subjects manifested evidence of an impairment on the Benton Test while only four subjects evidenced difficulty in remembering the paired associate list. Eight subjects did however exhibit an impairment in learning the paired associate list of words. Weingartner, Faillace and Markley (1970) observed that alcoholics learned more slowly than controls on two verbal learning tasks, serial and free recall.

Fitzhugh et al. (1960, 1965) reported that no significant differences existed between alcoholics and controls on the memory measure of the Tactual Performance Test.

The evidence to date is thus inconclusive. Verbal memory appears to be relatively intact (Claeson and Carlsson, 1970; Jonsson et al., 1962) while verbal learning might be impaired (Claeson and Carlsson, 1970; Weingartner et al., 1970). As far as figural or nonverbal memory is concerned, the results are equivocal. Two laboratories have reported an impairment (Claeson and Carlsson, 1970; Jonsson et al., 1962) while other investigators have found no sign of a deficit (Fitzhugh et al., 1960, 1965; May et al., 1970).

Conceptual Capacity

Alcoholics have been demonstrated to be deficient on a variety of cognitive tasks. Fitzhugh et al. (1960, 1965) observed that alcoholics performed significantly more poorly than controls on the Category Test of the Halstead-Reitan Battery. This finding has subsequently been replicated in our laboratory (Jones and Parsons, 1971). Goldstein and Chotlos (1965) administered the Category Test with a modified procedure and found no differences between alcoholics and controls. In the latter

investigation, the authors departed from the standardized procedure in two important ways. First, a three second delay was introduced between the response and the feedback which informed the subject as to whether or not his response was correct. Secondly, a correction procedure was instituted; that is, if the subject's response was incorrect, he was shown which response would have been correct. Thus the implementation of the delay and response correction procedures did not reveal a cognitive deficit previously observed on this task.

Several authors have investigated conceptual functioning within a stratified hierarchical framework. Lovibond and Holloway (1968) administered the Query Brain Damage Scale (a modification of the Goldstein Object Sorting Test) and found that deteriorated alcoholics performed at a significantly more concrete level than a group of chronic alcoholics who in turn performed more poorly than normal controls and schizophrenics. Reinehr and Golightly (1968) tested alcoholics on the Organic Integrity Test and found that nine of thirty subjects performed in the brain damaged range of functioning. Though this represents less than thirty percent of the sample, this finding is remarkable in that the level of abstraction required is very low. Reilly and Sugerman (1967) investigated conceptual ability in a social context. Employing the sentence completion test developed by Schroder and Streufert (1962), they found that only two of ninety-six alcoholics were able to function at the system III level out of a possible system IV. In addition, it was observed that system I alcoholics were more field-dependent than system II alcoholics. The authors interpreted their results by suggesting that alcoholics are concrete in their interpersonal interactions. However, even within the

alcoholic population they can be stratified as to the degree of concreteness. Furthermore, the more concrete the individual, the greater was his field dependency as indicated by performance on the Embedded Figures Test.

Alcoholics have been administered several different abstracting tasks that require the identification of verbal concepts. No evidence for an impairment has been observed on tests that require the identification of synonyms from a group of unrelated words (Claeson and Carlsson, 1970; Jonsson et al., 1962; Tarter and Jones, 1971b). Alcoholics have been reported in one study (Jonsson et al., 1962) to be impaired in comprehending the intrinsic abstract meaning of proverbs. In addition, alcoholics were found to be deficient at providing alternative meanings of homonyms. The ability to reason inductively appears to be intact. Administering Thurstone's (1938) Figure Classification Test, no indication of a deficit in this capacity was noted by Claeson and Carlsson (1970) and Jonsson et al. (1962).

Recently, Tarter and Parsons (1971) attempted to further elucidate the nature of the cognitive deficit. Administering the Wisconsin Card Sorting Test, it was observed that alcoholics performed at a level far inferior to controls, suggesting that the alcoholics were impaired at shifting concepts. But since the alcoholics tended to interrupt correct sequences of positively reinforced responses, thus inflating their trials and error scores, it could not be established for certain if their performance decrement was due to a cognitive rigidity in switching sets, or in persistence at maintaining the cognitive set. A cognitive set is defined as a mode of reinforced responding to a specific concept or dimension. Of particular interest in that study was the observation that the

two groups did not differ on the first set or concept, suggesting that the alcoholics were not deficient at identifying or learning simple concepts.

In another study, Jones (1971) administered an equivalent form of the Wisconsin Card Sorting Test in which the printed verbal descriptions of the stimulus dimensions were substituted for the geometric displays. No differences were noted between the alcoholics and controls suggesting that the previously reported deficits by Tarter and Parsons (1971) may be due at least in part to the visual spatial display of the stimuli.

In conclusion, it appears that alcoholics suffer from a cognitive or abstracting impairment. Within this dimension of psychological functioning however, the deficit is not pervasive in that it does not extend to all types of tasks. The performance decrement is most pronounced on tests that have a visual-spatial display of the stimuli but is seen also on some forms of verbal abstracting tasks. The limitation in conceptual capacity has in addition been demonstrated to generalize to the alcoholic's social interpersonal mode of functioning.

Neuropsychological Implications

From the preceding review, it is evident that alcoholics manifest certain relatively specific psychological deficits. One interpretation of these deficits is that they reflect a disruptive effect of chronic alcohol consumption on the brain and consequently upon behavior. The ensuing discussion will review the neuropsychological evidence that implicates an organic or neuropathological alteration in the brains of chronic alcoholics.

Chronic alcoholics have been found to perform at a level between

normal controls and acutely brain lesioned patients on the Halstead-Reitan Battery (Fitzhugh et al., 1960, 1965). The impairment index, a summary score describing the severity of the brain damage, was significantly higher in the alcoholics than the controls, suggesting central nervous system involvement. Claeson and Carlsson (1970) administered a battery of psychological tests to measure perceptual, intellectual, learning and memorial capacities. They found that of twenty chronic alcoholic subjects only three did not evidence any signs of impairment. Seven subjects were slightly impaired, five were moderately impaired and five were severely impaired.

In one study (Smart, 1965), indirect evidence was obtained to substantiate the hypothesis of a neuropathological condition consequential to chronic alcohol intake. Alcoholics were placed into one of two groups on the basis of their verbal-performance subscale IQ's on the WAIS. Subjects who obtained a discrepancy of scores greater than eighteen were assigned to one group while those with a difference of five IQ points or less to another group. Those subjects who obtained intermediate discrepancies were subsequently excluded from further investigation. The Maudsley Personality Inventory was then administered. It was hypothesized that the alcoholics with the larger verbal performance discrepancy would tend to be more extraverted. This hypothesis stems from the findings of several investigators (Meyer, 1961; Petrie, 1949; and Tow, 1955) who have reported that barin damage has extraverting consequences on behavior. The results confirmed the hypothesis, suggesting that the poorer performance IQ relative to the verbal IQ was due to a pathological change in the brain.

Cognitive tests are among the most accurate methods of detecting neurological impairment from psychological tests. Reitan (1955) found that the Category Test had a hit rate in excess of 90 percent in discriminating brain damaged from normal subjects. Goldstein (1942) has similarly claimed that the most dramatic consequence of brain damage is a loss of the "abstract attitude." Lovibond and Holloway (1968) using a modified scoring procedure of the Goldstein-Sheerer Test found a progressive decline in abstracting capacity with increasing duration of alcoholism. Alcoholics have been demonstrated to perform significantly more poorly than controls and at about the same level as neurological patients with diffuse or bilateral cerebral damage on the Category Test (Fitzhugh et al., 1960, 1965; Jones and Parsons, 1971). An impairment has also been noted on the Wisconsin Card Sorting Test (Tarter and Parsons, 1971), a test which also has been shown to be sensitive to detecting cerebral dysfunction (Milner, 1963). Thus conceptual tasks in which brain damaged patients are deficient, likewise result in a similar though not so severe an impairment in chronic alcoholics.

Another source of evidence implicating a neurological impairment derives from the field-dependent mode of perception in alcoholics. Although Witkin et al. (1962), Karp et al. (1965a, 1965b) and Karp and Konstadt (1965) have advanced the hypothesis that the field-dependent mode of perceptual functioning in alcoholics is etiological and reflects a personality predisposition; other investigators (Bailey et al., 1961; Goldstein and Chotlos, 1965) have postulated that the dependency is consequential to a history of alcoholism and is a manifestation of organic brain disease. Evidence advanced to support the predisposition hypothe-

sis is based upon the observations that sobriety does not alter the field-dependency (Karp et al., 1965a), no significant association is found betweer drinking history and severity of dependency (Karp and Konstadt, 1965) and the fact that the administration of alcohol to alcoholics does not result in any appreciable change in field orientation (Karp et al., 1965b). The evidence accrued which support an organic deficit interpretation is based upon the findings that chronic alcoholics are more field-dependent than any other psychopathological group (Elliott, 1961) and most approximate individuals with verified cerebral damage (Bailey et al., 1961). In addition, Goldstein, Neuringer, Reiff and Shelly (1968) observed that personality measures of dependency were not correlated with perceptual field-dependency in alcoholics. Because of the nature of the problem, it is however impossible to positively confirm either hypothesis. Since the field-dependent perceptual mode of functioning can be a result of either brain damage (Teuber, 1963) or personality variables (Witkin et al., 1954), longitudinal studies are necessary before either hypothesis can be confirmed.

The spatial deficits observed in alcoholics, particularly on the various block design tests and Trail Making Test also suggest that an organic impairment may be extant in alcoholics. In fact, Wechsler (1941) has speculated that the poor spatial functioning is almost pathognomonic of chronic alcoholism. Deficits in spatial ability generally implicate damage to the parietal and frontal areas of the brain (Teuber, 1963).

There is some indication that learning and memory may be disrupted in chronic alcoholics (Claeson and Carlsson, 1970; Weingartner

et al., 1971), although the evidence is as yet not conclusive. Thus there is an accumulating literature which implicates a neurological deficit in alcoholics. Since most of the research in this area was conducted in only the last decade, there are still many unanswered questions and unresolved problems. Hopefully continued neuropsychological research will not only shed more light on the nature and severity of the psychological impairment, but will also help specify where in the brain the pathological changes occur. Recent investigations by Jones and Parsons (1970) and Tarter and Parsons (1971) have indicated that such an approach may have value in understanding the disease process in alcoholism as well as to further an understanding of brain mechanisms in general.

CHAPTER II

STATEMENT OF THE PROBLEM

It is apparent from the preceding review that there are still many unanswered questions pertaining to the nature and extent of psychological deficit in alcoholics. One dimension of functioning, namely abstracting capacity, has been of particular interest to this author. Because cognitive tests are very accurate in discriminating normal from brain-damaged subjects (Reitan, 1955), it was thought that the assessment of conceptual capacities would contribute to an understanding of the type and severity of psychological deterioration that may be extant in chronic alcoholics.

The deficit manifested by alcoholics on the Categories Test (Fitzhugh et al., 1960, 1965; Jones and Parsons, 1971), is descriptive of the cognitive impairment but does not explain it. Since the Categories Test is comprised of seven subtests, it was speculated (Tarter and Parsons, 1971) that the deficient performance on this task might reflect an inability on the part of the alcoholic to change their cognitive set in accordance with the requirements of the particular subtest. To formally test this notion of cognitive rigidity, the Wisconsin Card Sorting Test was administered to a group of normals, and alcoholics. The subjects were required to identify three different concepts (color, shape

and number) twice to a criterion of ten consecutive correct responses. Thus there were six sets and after each set was learned to criterion, it was switched to another dimension without informing the subject. In this way, it was hoped to determine if chronic alcoholics have difficulty in shifting concepts that may be due to cognitive rigidity or inflexibility. It was also theorized that if alcoholics were impaired at switching sets, they might exhibit less "learning to learn" or interproblem improvement across successive set shifts.

A clear answer to the originally posed questions was not obtained. Alcoholics did perform significantly more poorly than controls, but this did not appear to be due to an inability to switch sets. Nor did the groups differ on the number of perseverative responses emitted immediately after a set change. Moreover, neither group manifested an improvement in performance across sets, suggesting that six sets were not sufficient to evaluate "learning to learn" capacity.

One interesting finding was that the alcoholics tended to interrupt a correct sequence of five or more correct responses with an error more than did the controls. This difference approached but did not reach statistical significance. However, when the alcoholic group was divided into two subgroups on the basis of whether or not they manifested either zero or one or more interruptions, it was observed that those subjects who did interrupt a correct sequence of responses with an error had been drinking longer than the other subgroup of alcoholics. This difference was significant.

Three important problems still remain to be investigated which were not resolved in the first study (Tarter and Parsons, 1971). First,

if "learning to learn" ability is to be evaluated, the number of learning sets must be increased. Second, the relationship between alcoholism history and response sequence interruptions merits further investigation. The association between these two variables was discovered in the first experiment in post hoc fashion, but a more suitable experimental method would be to pre-experimentally assign subjects to different groups on the basis of the duration of their alcoholism history. And thirdly, it remains to be determined if alcoholics are impaired at set-shifting in a paradigm that is not confounded by the occurrence of response sequence interruptions. Hence, set-shifting can be investigated independently from set maintainance.

Two experiments to be reported herein systematically examine each of these dimensions of cognitive functioning. In Experiment I, the subject is allotted a maximum of eighteen sets for interproblem improvement or "learning to learn" to ake place. In addition, by operationally defining the duration of alcoholism into long- and short-term, the association between drinking history and cognitive set inpersistence can be established. Experiment II investigates set shifting ability in a procedure which does not permit the occurrence of set interruptions. By switching the set after three consecutive correct responses there is no possibility of interrupting a sequence (defined as five or more responses) of correct responses with an error.

A third experiment, more speculative than the other two, is also suggested. It has been reported from neuroanatomical investigations that alcoholics suffer from a differentially greater impairment of the frontal (Alexander, 1941; Courville, 1955) and frontal-limbic (Creutzfeldt, 1928)

regions than other regions of the brain. Neurological examination has buttressed the anatomical findings of central nervous system dysfunction in the frontal areas (Lereboullet and Pluvinage, 1956; Lereboullet, Pluvinage and Amstutuz, 1956; Tumarkin, Wilson and Snyder, 1955). Because the orbital and lateral prefrontal areas are anatomically connected to the limbic regions (Nauta, 1964), it is possible that the two regions though geographically separated participate conjointly in psychological functioning. Indeed, such a theory has already been advanced by Pribram (1960) who postulated that the prefrontal areas are essential for the planning of actions, while the limbic structures are necessary for the execution of the plans.

Behavioral analyses of frontal and limbic lesions in man have revealed three characteristic deficits which are also under investigation in the present study. Milner (1963) and Talland (1965) reported deficits in shifting concepts and response sequencing in frontal and limbic lesioned subjects, respectively. Investigations with animals (Mishkin, 1964) have demonstrated a "learning to learn" deficit in frontally ablated monkeys. Thus Experiment III will be conducted with the aim of further elucidating the possible neurological involvement of the frontal and limbic regions of the brain in chronic alcoholics. Several psychological tests which have formerly been demonstrated to differentiate patients with frontal damage from patients with lesions to other areas of the brain will be administered to alcoholic and control subjects. In this way it will be determined if alcoholics exhibit analogous deficits to those observed in frontally lesioned subjects. In addition it is hoped that the utilization of these tests that tap spatial, per-

ceptual and attentional abilities will shed more light on the nature of the impairment in alcoholics at the psychological level of analysis.

To briefly recapitulate, the problems to which this dissertation is addressed are:

1. The "learning to learn" capacity of alcoholics (Experiment I).

2. The relationship between response sequence interruptions or cognitive set impersistence with duration of alcoholism history (Experiment I).

3. The ability of alcoholics to shift cognitive sets in a procedure that is not confounded with the variables pertaining to the maintenance of the set (Experiment II).

4. The question of whether or not alcoholics suffer from the same behavioral deficits that are seen in patients with verified frontal and limbic lesions, thus implicating these regions as explanatory constructs for the psychological impairment (Experiment III).

CHAPTER III

EXPERIMENT I: INTER- AND INTRA-PROBLEM PERFORMANCE OF ALCOHOLICS ON A CONCEPT IDENTIFICATION TASK

It has been previously reported (Tarter and Parsons, 1971) that alcoholics manifest a cognitive impairment as determined by their performance on the Wisconsin Card Sorting Test. Though the alcoholics performed at a level inferior to the controls, neither group exhibited an improvement in performance across learning sets, indicating that not enough sets were administered to be able to evaluate "learning to learn" capacity. Thus the ability of alcoholics to shift concepts with facility across a sequence of different cognitive sets was not determined.

One result which did discriminate the groups was the finding that the alcoholics tended to interrupt a correct sequences of responses with an error more than did the controls. However, this difference approached but did not attain statistical significance. Within the alcoholic group, the propensity for manifesting task interruptions was significantly associated with the duration of alcohol consumption; the longer the individual had been drinking alcohol, the greater was the number of set interruptions. These results were interpreted by the authors as reflecting an impairment in alcoholics in maintaining or persisting with a cognitive set.

The present investigation sought to further clarify the two

points of interest mentioned above. First by extending the number of learning sets from six to a maximum of eighteen, "learning to learn" ability could be competently evaluated. And secondly, by pre-experimentally assigning the alcoholics to one of two groups on the basis of the duration of alcoholism history, the relationship between response sequence interruptions and alcohol consumption history could be more precisely evaluated.

Method

Subjects

Two groups of 15 alcoholics each and one group of 15 normal controls participated in this investigation. Participation was on a voluntary basis. All of the subjects were inpatients at the Oklahoma City Veterans Administration Hospital.

The first group of alcoholics admitted to being an alcoholic for ten years or less ($\bar{X} = 4.5$), while the second group of alcoholics described themselves as being alcoholic for a period in excess of ten years ($\bar{X} = 17.5$). The information pertaining to their drinking history was obtained from a personal history questionnaire completed by each patient upon admission to the hospital. A ten-year history of alcoholism as the cutting point in dichotomizing the sample of alcoholics into two groups was employed not out of any theoretical bias, but instead it was utilized because it enabled the two groups of alcoholics to be easily matched on the variables of age and education. For purposes of convenience only, the group which described themselves as being alcoholic for ten or less years will be henceforth called short-term alcoholics, while

those who admitted to being an alcoholic for longer than ten years will be labelled long-term alcoholics.

The alcoholic subjects were all participants in a ninety-day program designed specifically for the treatment of chronic alcoholism. Throughout their term in the program, they participated in group psychotherapy as well as the other therapies such as industrial, physical and occupational. Patients with a history of psychosis or acute neurological disease (as determined from their medical and EEG examination) were not included in the investigation. Experimentation was commenced after the patients had been in the program for at least four weeks to allow ample time for the effects of acute alcohol withdrawal to subside.

The controls were selected from the general medicine wards. None had an alcoholic, neurological or psychiatric history. In addition, none of the patients were on a regimen of psychotropic drugs.

All subjects were administered the Shipley-Hartford Institue of Living Scale. This test provides information pertaining to the individual's intellectual competence expressed in the indices of verbal age, abstracting age and conceptual quotient (CQ). The total raw score of the Shipley can also be converted into the WAIS equivalent full scale IQ (Paulson and Lin, 1970).

In Table 1 are presented the means and standard deviations for all three groups on the variables of age, education, Shipley-Hartford scores and WAIS equivalent IQ. Comparisons between the groups on each of these variables did not reveal any significant differences.

Procedure

The Wisconsin Card Sorting Test was individually administered

TABLE 1

MEANS AND STANDARD DEVIATIONS FOR AGE, EDUCATION, SHIPLEY-HARTFORD SCORES AND WAIS EQUIVALENT IQ

Variable	Controls		Short-term Alcoholics		Long-term Alcoholics	
	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Age (Years)	43.0	10.8	42.2	8.4	47.1	6.3
Education (Years)	11.7	2.5	12.2	1.5	11.4	2.1
Verbal Age (Years)	16.0	2.3	16.1	2.3	16.3	2.0
Abstract Age (Years)	13.7	3.1	14.2	2.4	13.7	3.2
Conceptual Quotient	85.9	18.4	88.9	15.0	83.4	15.6
WAIS FS IQ	105.2	13.5	105.6	9.5	106.2	12.8

to each subject. The stimulus materials were prepared according to the procedure described by Berg (1948) and Grant and Berg (1948). The test materials consist of sixty-four 3"x5" cards. On each card was drawn one of four geometric figures (circles, squares, triangles or diamonds). On any given card there were from one to four figures, all of the same type. The geometric figures were colored either red, green, yellow or blue. Only one color code was employed on any given card. Thus this concept identification test consists of three different dimensions (shape, number and color) and four levels within each dimension, yielding sixty-four possible permutations; hence, one card for every permutation.

Four of the cards were presented on a table in a horizontal row before the subject. The stimulus properties of each of those cards proceeding from left to right were: one red triangle, two green diamonds, three yellow squares and four blue circles. The remaining cards were placed in random order in a small file box so that the stimulus properties on each card faced away from the subject. In this manner the subject could inspect only one card at a time, namely the one he was holding and preparing to sort.

The following instructions were then administered to the subject:

> "Look carefully at these four cards. You can see that they are different from each other in several different ways. In that box (E points at the file box) there are many other cards. All of them are different from these four cards and all are different from each other. No two cards

are ever exactly alike. However, each of those cards in the box has some characteristic or similarity in common with one of these four cards. It is your job to figure out what that characteristic is and to use that idea to match up each of those cards in the box with one of these four cards. When you begin, you will take a card from the box one at a time and place it below one of these cards (E points to the places below the four stimulus cards) according to how you think that card should be matched up. I will then say either 'right' or 'wrong.' If I say 'right,' that means that you are using the correct idea to match up the cards. If I say 'wrong,' that means that you are not using the correct idea to match up the cards. Thus it is your task to figure out how the cards should be matched up.

You can take as much time as you like. There is no time limit so you can go as fast or as slow as you want. There is only one restriction and that is, once you have placed a card down according to your choice, don't move that card to another position if I say 'wrong.' Do you understand what to do? Do you have any questions?"

Throughout the testing, the subject was allowed only one available instance; that is, he could view only the last card he placed down

below each of the four stimulus cards. After the deck had been exhausted, all except the top card in each of the four positions were randomized by shuffling them a few times, and then they were placed as before in the file box. The subject was then instructed to continue sorting as before.

The task was structured so that the subject had to identify the concepts in the order of color, shape and number, each to a criterion of ten consecutive correct responses. After the first set (color) was learned to criterion, the dimension was shifted unknowingly to the subject to the subsequent concept (shape) which after criterion performance was attained was changed to the next concept (number). This cycle was then repeated until the subject attained the criterion of three consecutive sets in fifteen trials or less. If this was not possible, the task was terminated after eighteen sets. Therefore the minimum number of sets possible was six while the maximum number was eighteen.

Results

Five indices of performance were recorded. They were the following: 1) number of trials to criterion, 2) total number of errors, which in turn was broken down into 3) perseverative errors, 4) 'other' errors and 5) perseverative errors within the first ten trials after a set change. The tirals and total errors scores were derived for each set. The remaining measures were computed beginning from set number two, since by definition a perseverative and 'other' error could not occur on the first set. A perseverative error was defined as a response that was incorrect on the current set but would have been correct on the immediately preceding set. An 'other' error was identified as an incorrect response which was not perseverative.

Because the criterion for successful completion of the task was three consecutive sets with a maximum of fifteen trials on each, it was to be expected that most subjects would attain the criterion before the allotted number of eighteen sets. However, in order to maintain a balanced matrix of scores, subjects who reached criterion prior to the eighteenth set were assigned the minimal number of trials (10) and errors (0) scores for each subsequent set after the three criterion sets. This procedure has the advantage of rendering the data more amenable to analysis and was not considered to prejudicially represent the results since the scores were assigned to those sets beyond which the subject had already demonstrated mastery of the task.

The raw scores were then transformed using the equation $y = \sqrt{x + 1}$. The square root transformation has been recommended for use where extreme scores can produce a skewed distribution (Bartlett, 1936) and has previously been suggested for application in Wisconsin Card Sorting Test data (Grant and Cost, 1954). The number of perseverative errors emitted within the first ten trials after a set change was not transformed since the number of trials was fixed, thus preventing the occurrence of extremely deviating scores.

The eighteen sets were then collapsed into six cycles. The mean score for every three sets was computed for each individual and the resulting value was the assigned score for that particular cycle. A slightly different procedure was employed for the two measures of perseverative errors and for the index of 'other' errors. Since no values were obtained on the first set for these indices, the first cycle was computed by deriving the mean score from only the second and third sets.

The subsequent cycles were all comprised of three sets each, and were derived in identical fashion with the trials and total errors measures. Thus with the minor exception noted above, each cycle consisted of the mean score of three sets.

The data were then submitted to a 3 (groups) x 6 (cycles) x 15 (subjects) analysis of variance. In Table 2 are presented the F-ratios for the main effects of "Groups," "Cycles" and the "Groups x Cycles" interaction.

With the exception of the number of perseverative errors emitted within the first ten trials after a set shift which was significant beyond the .05 level of significance, all the other measures on the main effect for groups were significant beyond the .01 level. Neuman-Keuls Tests were then computed and it was found that both the controls and short-term alcoholics performed significantly better than the long-term alcoholics on all measures while the former two groups did not differ from each other. This difference was significant beyond the .05 level for the number of perseverative errors emitted within the first ten trials after a set change, and exceeded the .01 level on all of the other measures.

It can also be seen from Table 2 that the main effect for cycles was significant for each measure beyond the .01 level of significance, indicating that a change in performance competency occurred across cycles.

In Figures 1 and 2 are illustrated the performance curves, indicating an improvement across cycles. The perseverative and 'other' errors indices are presented in Table 3. They are described by the same

TABLE 2

SUMMARY OF ANALYSES OF VARIANCE ON EACH MEASURE

Source	df	MS	F	p <
Trials				
Groups	2	41.45	8.393	.01
Cycles	5	8.10	12.397	.01
Groups x Cycles	10	0.35	0.539	ns
Total Errors				
Groups	2	34.33	8.770	.01
Cycles	5	10.93	21.950	.01
Groups x Cycles	10	0.37	0.740	ns
Perseverative Errors				
Groups	2	19.61	6.897	.01
Cycles	5	7.08	19.349	.01
Groups x Cycles	10	0.31	0.841	ns
'Other' Errors				
Groups	2	8.10	8.319	.01
Cycles	5	1.89	11.159	.01
Groups x Cycles	10	0.18	1.082	ns
Perseverative Errors Within 10 Trials after a Set Shift				
Groups	2	27.81	3.590	.05
Cycles	5	39.62	28.090	.01
Groups x Cycles	10	0.85	0.600	ns

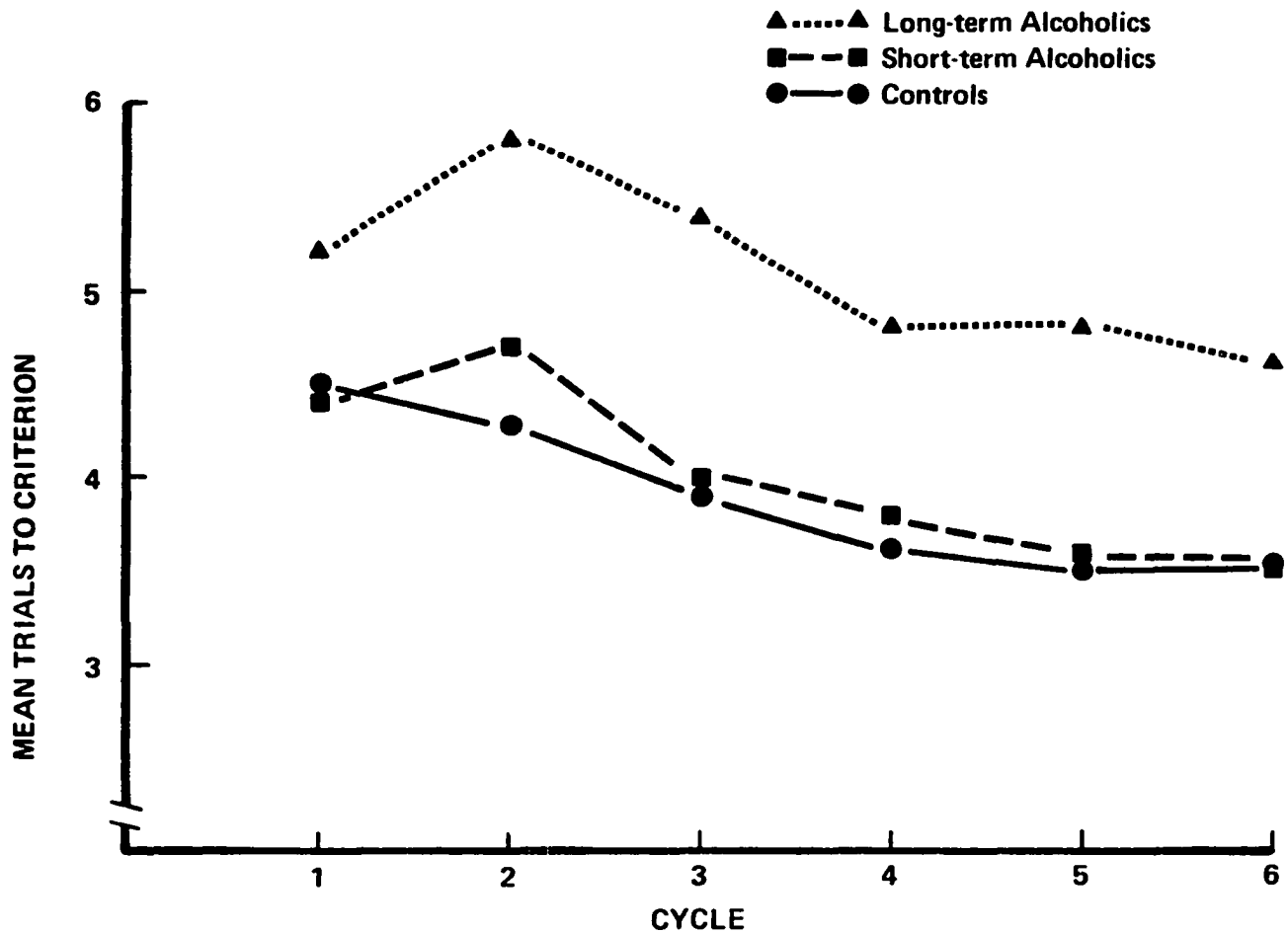

Figure 1. Mean trials to criterion on each cycle for the controls, short- and long-term alcoholics.

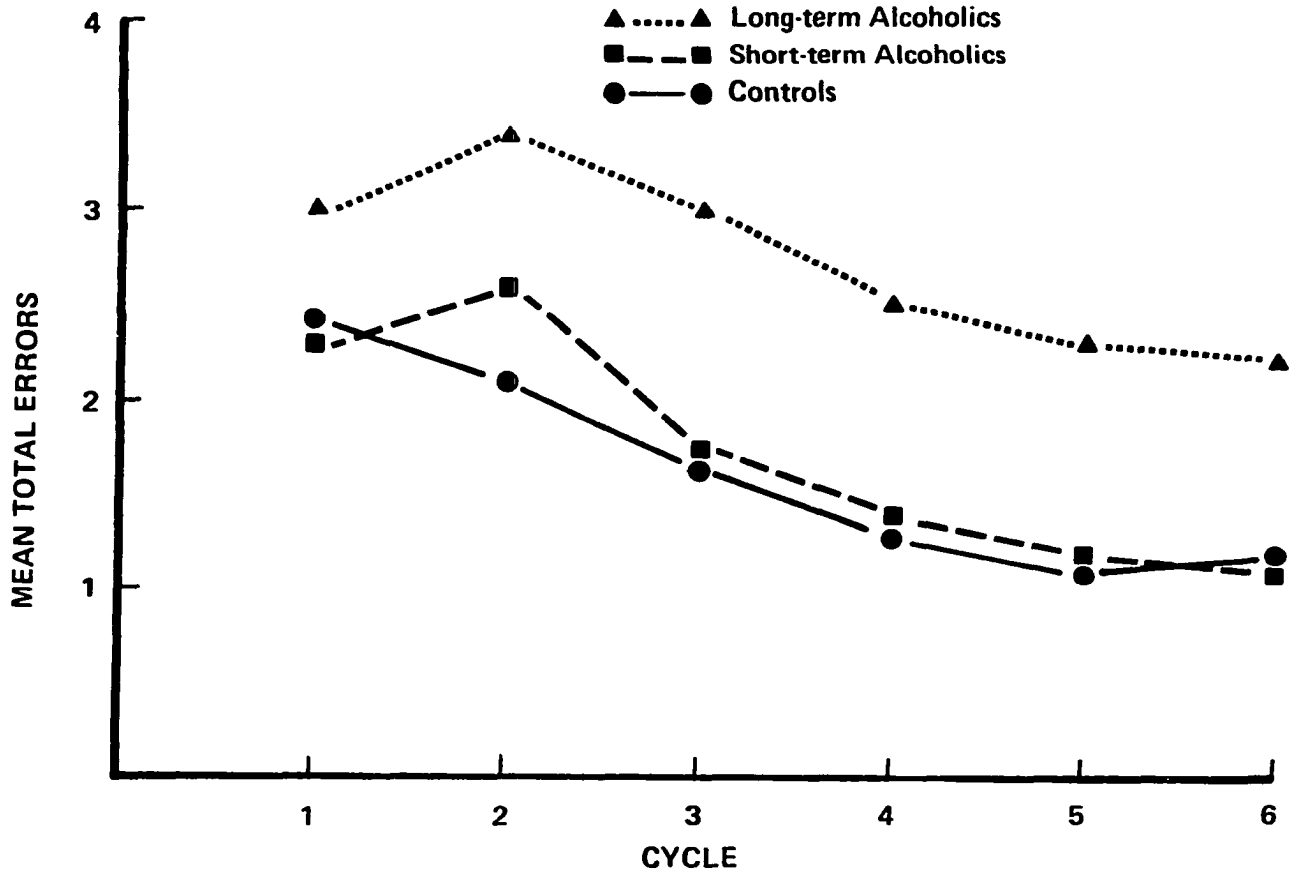

Figure 2. Mean total errors on each cycle for the controls, short- and long-term alcoholics.

TABLE 3

MEAN SCORES FOR EACH GROUP ON PERSEVERATIVE AND 'OTHER' ERRORS

Variable	Cycle					
	1	2	3	4	5	6
Perseverative Errors						
Controls	2.236	1.846	1.578	1.380	1.266	1.244
Short-term Alcoholics	2.347	2.077	1.515	1.315	1.135	1.138
Long-term Alcoholics	2.671	2.833	2.508	2.211	2.037	2.128
'Other' Errors						
Controls	1.572	1.469	1.284	1.196	1.155	1.102
Short-term Alcoholics	1.561	1.662	1.271	1.240	1.142	1.078
Long-term Alcoholics	1.814	2.213	2.042	1.654	1.650	1.607

performance curves as the trials and total errors measures. The number of perseverative errors emitted within the first ten trials after a set shift takes a somewhat different function across cycles, and is described in Figure 3.

The groups x cycles interaction was not significant, demonstrating that the groups performed in a similar manner across cycles, the difference being mainly a quantitative one with the long-term alcoholics exhibiting a consistent decrement relative to the other two groups. The significance levels were not altered after "conservative" estimates (Winer, 1962, pp. 305-306) were obtained for each measure on the within-subject effects, namely cycles and groups x cycles.

To evaluate "learning to learn" capacity, the percent total errors was computed for each cycle. The percentage measure is typically employed to assess interproblem performance (Harlow, 1959). The data were then submitted to an analysis of variance and the results are summarized in Table 4.

TABLE 4

SUMMARY OF ANALYSIS OF VARIANCE ON PERCENT ERRORS

Source	df	MS	F	p <
Groups	2	3500.06	8.986	.01
Cycles	5	2165.05	22.698	.01
Groups x Cycles	10	53.28	0.558	ns

The main effect for groups was highly significant. Upon computation of the Neuman-Keuls Test, it was observed that the long-term alco-

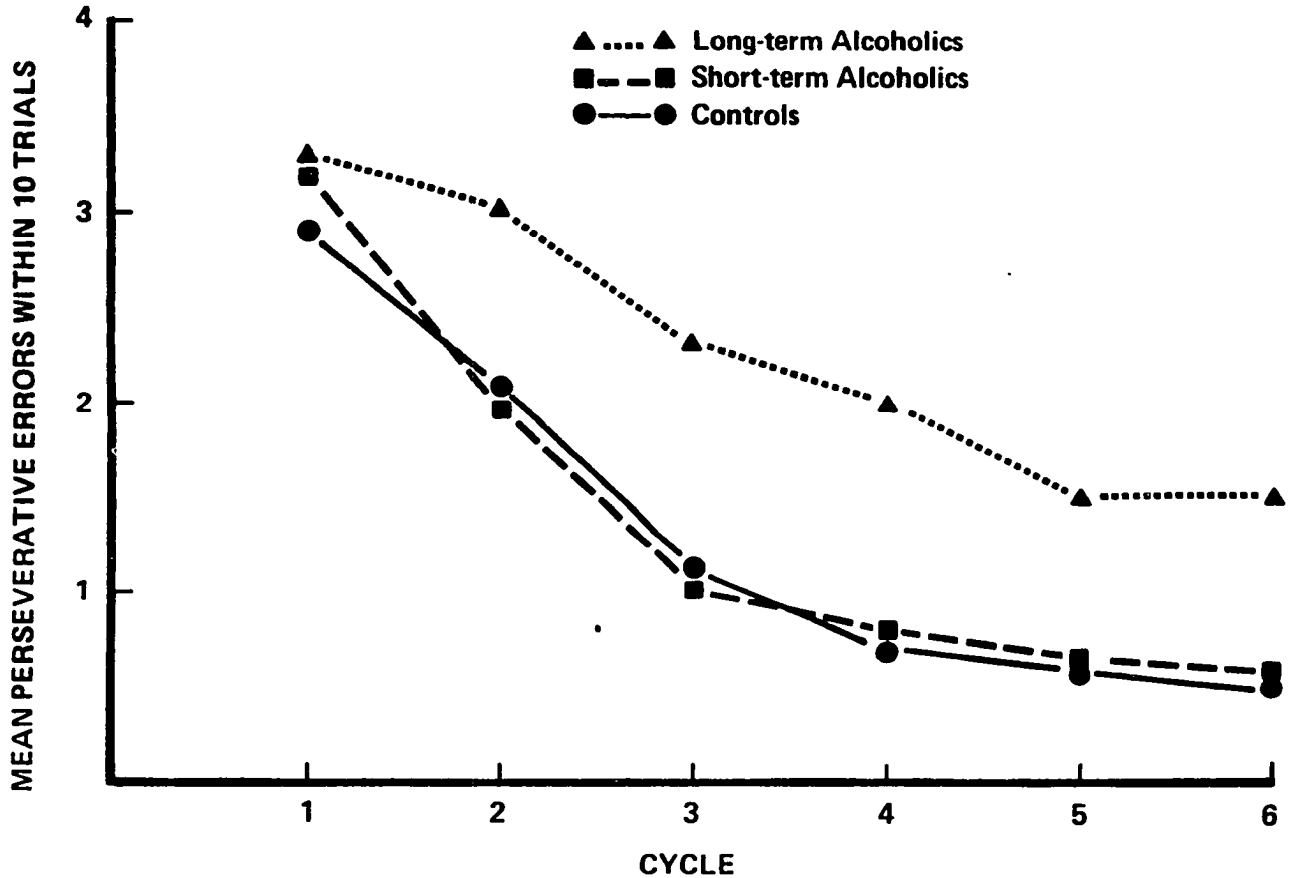

Figure 3. Mean perseverative errors emitted within the first ten trials after a set shift on each cycle for the controls, short- and long-term alcoholics.

holics performed significantly more poorly ($p < .01$) than both the controls and short-term alcoholics, while the latter two groups did not differ from each other. The significant main effect for cycles suggests an improvement in performance across cycles. To precisely describe the improvement, regression coefficients were derived for each group. The coefficients for the controls, short- and long-term alcoholics are -3.31, -4.20 and -3.14, respectively. Applying these values in the regression equation $y = bx+a$, it can be seen in Figure 4 that the groups improve across sets in a parallel manner. Thus the rate of improvement is similar in all three groups, a conclusion buttressed by the observation of a nonsignificant groups x sets interaction.

In summary, it appears that "learning to learn" capacity, as defined by the rate of interproblem improvement, is not impaired in chronic alcoholics. The long-term alcoholics do perform more poorly than the other two groups on each cycle, but as will be demonstrated later, this reflects within set difficulties and not a deficit in "learning to learn."

The second problem to which this experiment was addressed concerned the capacity of alcoholics to persist with or maintain a cognitive set. In Figure 5 it can be seen that the probability of emitting an incorrect response is greater given a prior sequence of correct responses in the alcoholics than controls. Furthermore, the propensity for emitting a wrong response after a series of correct ones is greater for the long-term alcoholics than the short-term alcoholics who in turn exhibit a greater tendency to interrupt a correct sequence of responses with an error than controls. Note from Figure 5 that the differences between the groups are greatest in the middle segment of the ten trials

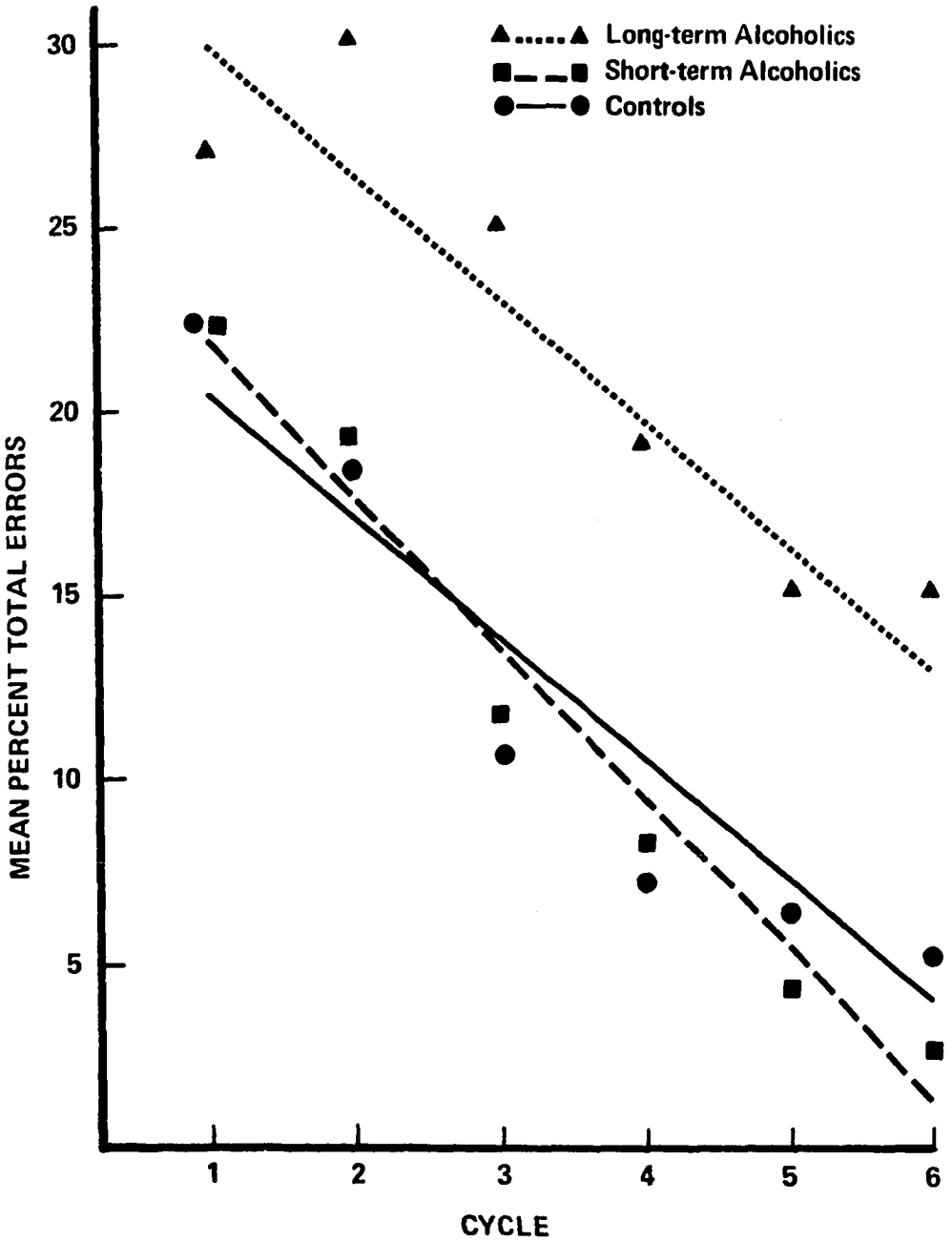

Figure 4. "Learning to learn" curves for the controls, short- and long-term alcoholics.

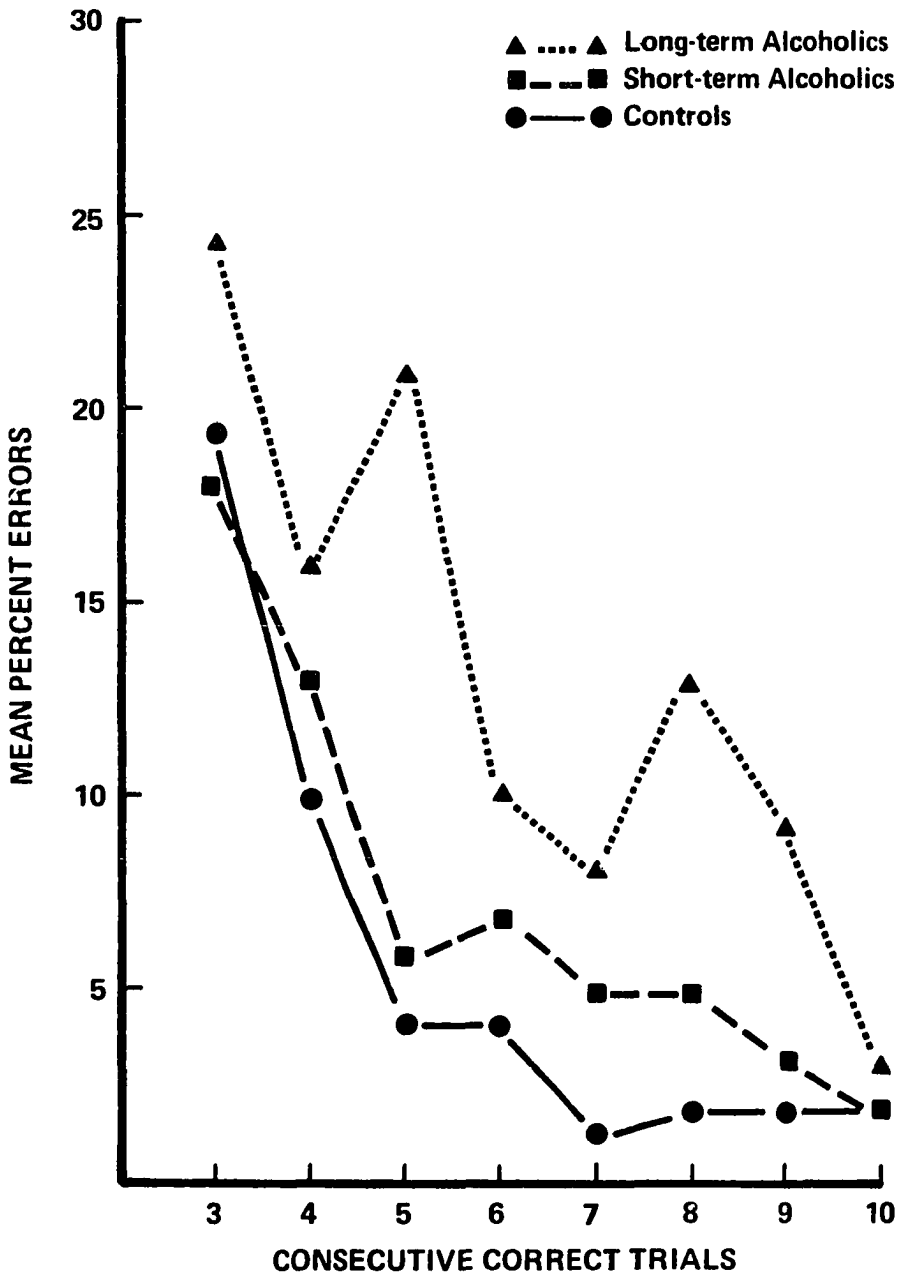

Figure 5. Percentage of times that an error succeeded a sequence of consecutive correct responses.

sequence. If two correct responses in a row were emitted, the probability of the third one being wrong is .24 in the long-term alcoholics, .18 in the short-term alcoholics and .19 in the controls. At the criterion level of ten consecutively correct trials, observe that if the previous nine trials were correct, the probability of making an error on the tenth trial is .02 for the controls and short-term alcoholics and .03 for long-term alcoholics. Hence, it appears that if a correct sequence of responses are emitted, the probability of the subsequent response in the series being an error is greater in the long-term alcoholics than the short-term alcoholics who in turn exhibit a greater inclination the the controls. The data presented in Figure 5 are averaged across all sets for each subject and since the set was switched after ten successive correct choices, the sequential probabilities are plotted only up to ten trials.

In another test to evaluate set persistence, the number of instances in which a correct sequence of five or more responses was followed by an error was tabulated for each subject. The probability of obtaining five correct responses in a four-choice situation by chance alone is $(1/4)^5$ or 1/1,024. It is therefore highly unlikely that such a run will occur by chance alone. Since the number of sets to criterion varied among the subjects, the number of interruptions was divided by the total number of sets required by the individual and the resulting quotient multiplied by 100 to yield the percent of interruptions (defined by five or more responses that is followed by an error) per set. In Table 5 is presented the mean and standard deviation of the percent of interruptions per set for each group.

It can be observed that there was greater performance variability in the alcoholics than controls. To formally examine this possibility Cochran's Test of homogeneity of variance was calculated (Winer, 1962) and it was found that the variance was not homogeneously distributed ($C = 0.761$, df 2/14, $p < .01$). Therefore the groups were statistically compared by the nonparametric Mann-Whitney U Test and it was observed that controls committed less response sequence interruptions than the short- ($U = 61$, $p < .05$) and long-term alcoholics ($U = 44$, $p < .02$). The differences between the latter two groups approached, but did not attain statistical significance ($U = 70.5$, $p < .10$).

TABLE 5

MEANS AND STANDARD DEVIATIONS FOR THE PERCENT OF INTERRUPTIONS PER SET FOR EACH GROUP

Group	$\bar{X}$	s
Controls	12.82	11.92
Short-term Alcoholics	26.93	20.10
Long-term Alcoholics	53.00	41.77

The results of these analyses indicate that the alcoholics had a greater propensity than controls to interrupt a positively reinforced correct sequence of responses with an error. Within the alcoholics, there was a tendency for the long- to commit such an interruption more often than short-term alcoholics but this difference did not reach statistical significance.

An analysis of error patterns was computed to determine if al-

coholics could utilize the information from an incorrect response to emit a correct response on the next trial. In Figure 6, it can be observed that the percentage of times the long-term alcoholics committed an error was greater than the other two groups if the preceding sequence of responses were also incorrect. Note from Figure 6 that if between one and three consecutive trials were incorrect responses, the probability that the immediately subsequent response being incorrect is quite similar for all three groups. However, the long-term alcoholics exhibited a greater inclination than the other two groups to persist with an incorrect mode of responding where a sequence of more than three errors in a row had been committed. The short-term alcoholics performed slightly better than the controls in utilizing the information contained in an error response, but as will be demonstrated below, this difference is not significant.

To formally test the hypothesis that the long-term alcoholics were deficient at utilizing an error response to achieve a subsequent correct response, the percent of times per set that a sequence of five or more errors in a row that was emitted was tabulated. The mean and standard deviation for each group are presented in Table 6.

TABLE 6

MEANS AND STANDARD DEVIATIONS FOR PERCENT OF TIMES PER SET THAT AN ERROR SEQUENCE OF FIVE OR MORE CONSECUTIVE INCORRECT RESPONSES WAS COMMITTED BY EACH GROUP

Group	$\bar{X}$	s
Controls	22.53	23.20
Short-term Alcoholics	17.46	32.68
Long-term Alcoholics	53.33	33.47

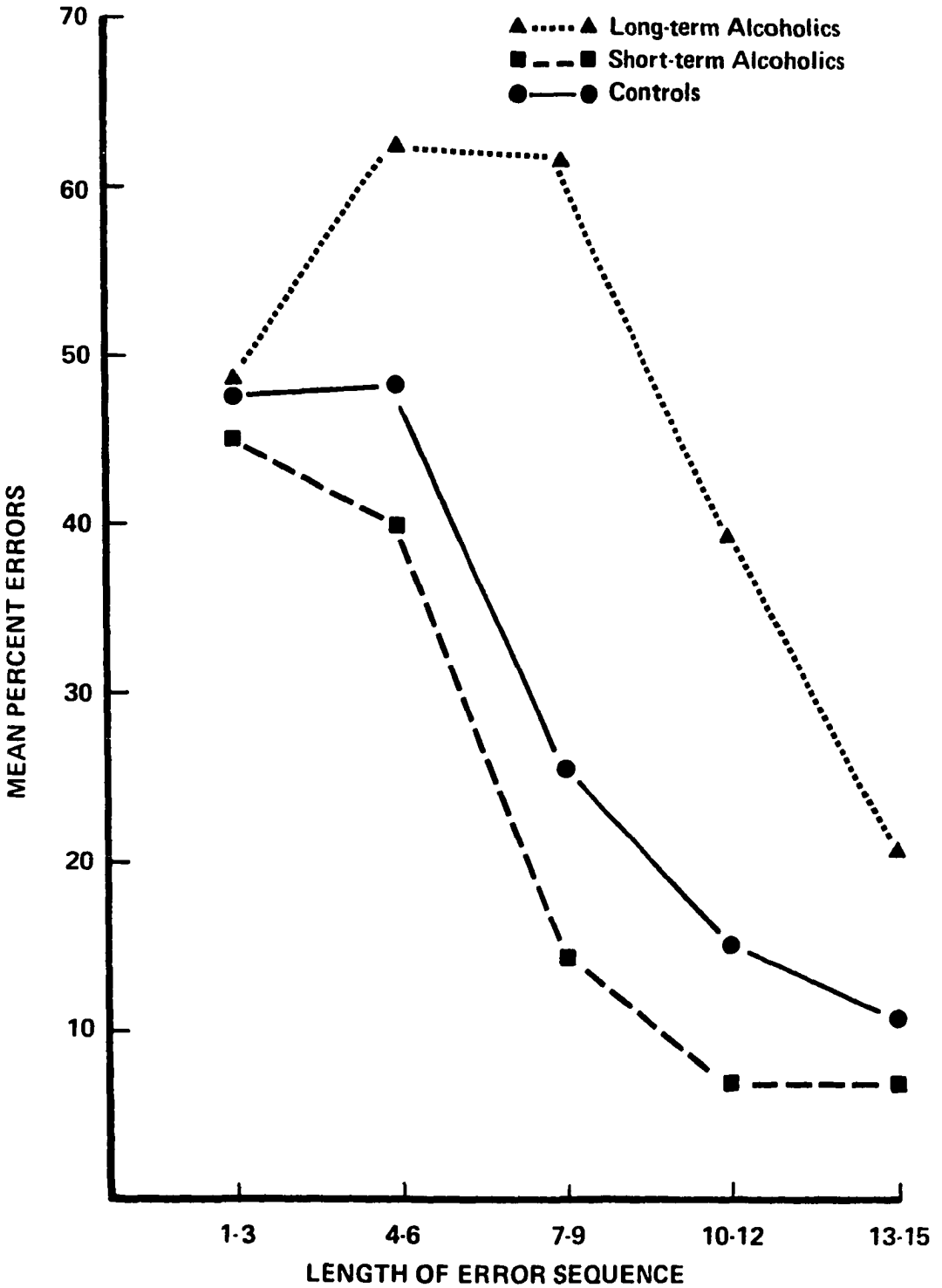

Figure 6. Percentage of times that an error succeeded a sequence of consecutive incorrect responses.

Cochran's C test was computed and it was observed that the variances of the three groups were homogeneously distributed (C = 0.411, df 3/14, ns). Therefore *t*-tests for independent samples were computed and it was found that the long-term alcoholics manifested significantly more error sequences than both the controls (t = 3.080, df 28, $p < .01$) and short-term alcoholics (t = 3.042, df 28, $p < .01$) while the latter two groups did not differ from each other (t = 0.510, df 28, ns). It is thus concluded that the long-term alcoholics have a greater propensity for maintaining an extended run of incorrect responses than the other two groups. This inclination as can be seen in Figure 6 does not emerge at the beginning of a sequence of errors but rather becomes manifest after three consecutive errors have been emitted.

The question can be raised that the long-term alcoholics manifest runs of incorrect responses simply because they have a greater propensity to make more errors than the other two groups. Though there is no direct evidence to either confirm or refute this possibility, there is some indication that this is not the case. For example, it can be noted in Figure 6 that the long-term alcoholics differ most from the other two groups in the middle of the response sequence and not in the beginning of the series as would be expected if it was only a matter of a greater tendency to emit an erroneous response. Thus the propensity for emitting a succession of errors does not become manifest at the outset, but emerges after a sequence of three incorrect responses. Similarly, the number of interruptions of correct sequences of responses with an error also is greatest between the groups in the middle of the series of trials.

The cognitive impairment demonstrated by the long-term alcoholics

is not due to a reduced conceptual capacity per se. By comparing the groups on the first set where no interference from set shifting has occurred, the capacity of the alcoholics to identify simple concepts can be evaluated. In Table 7 are presented the means and standard deviations of the raw scores for trials and total errors on the first set.

TABLE 7

MEANS AND STANDARD DEVIATIONS FOR TRIALS AND TOTAL ERRORS ON THE FIRST SET

Group	Trials		Total Errors	
	$\bar{X}$	s	$\bar{X}$	s
Controls	19.4	10.9	4.4	4.1
Short-term Alcoholics	14.5	6.8	2.2	2.3
Long-term Alcoholics	32.5	42.3	13.7	25.8

Because the variances for the trials ($C = 0.915$, df 3/14, $p < .01$) and total errors measures ($C = 0.966$, df 3/14, $p < .01$) were not homogeneously distributed, the Kruskall-Wallis Test was computed for each index. Neither the trials ($H = 5.166$, df 2, ns) nor errors measures ($H = 2.015$, df 2, ns) differentiated the groups. Paired comparisons between the groups by means of Mann-Whitney U tests also revealed no differences. The conclusion is therefore drawn that the ability to identify simple concepts is intact in chronic alcoholics.

Discussion

The results of this investigation are very clear. With respect

to the general question pertaining to the adequacy of performance on the Wisconsin Card Sorting Test, it was found that the long-term alcoholics took more trials and committed more errors than the short-term alcoholics and controls while the latter two groups did not differ from each other. The long-term alcoholics also obtained greater percent error scores on each cycle than the other two groups. Evidence was obtained which suggested that the long-term alcoholics also had difficulty in shifting sets as indicated by the significantly greater number of perseverative errors they emitted within the first ten trials after a set change. No difference was noted between the short-term alcoholics and controls on this measure.

"Learning to learn," or the rate of interproblem improvement across successive sets was not different between the groups. The rate of improvement between the groups was in fact very similar. The long-term alcoholics, though learning at a comparable rate with the other groups, did perform more poorly on each cycle. This inflation of percent errors in the long-term alcoholics is postulated to be due to the fact that they manifested a greater propensity than the other two groups to have an error response succeed an error. The net effect of this mode of cognitive functioning, which incidentally is also observed in frontally lesioned animals (Miles, 1964), is a larger number of strings or runs of incorrect responses, thus augmenting the percent of errors per cycle.

One of the most impressive results of this experiment was the finding that the ability to maintain a cognitive set was impaired in chronic alcoholics. This is illustrated by the observation that the al-

coholics interrupted a correct sequence of responses with an error more often than the controls. A deficit in sustaining a pattern of search and persistence has been reported in patients suffering from the Wernicke-Korsakoff Syndrome (Talland, 1965). This impairment of functioning along a temporal continuum in Korsakoff patients has also been described as an "agnosia" for succession (Williams and Zangwill, 1950) or as an inability to comprehend a sequence of events (Lidz, 1942). The impairment of the alcoholics reported herein is similar in that the alcoholic is incapable of sustaining a correct sequence of responses over time. One import of this finding is that the temporal sequencing deficit, once believed to be characteristic of the Wernicke-Korsakoff Syndrome (Talland, 1965) is also extant in the less deteriorated alcoholic.

In conclusion, the only difference noted between the controls and short-term alcoholics on the Wisconsin Card Sorting Test was the latter group's relative inability to maintain a cognitive set. The long-term alcoholics on the other hand exhibited a deficit in sustaining a positively reinforced cognitive set, but also took more trials and committed more errors than the controls and short-term alcoholics. In addition, they evidenced an impairment in shifting cognitive sets as indicated by the greater number of perseverative errors emitted immediately after a set change. There was a greater propensity on the part of the long-term alcoholics to have an error response follow an error more than the other two groups. In other words, they were impaired at utilizing the information contained in an erroneous response to achieve a subsequent correct response. Thus the short-term alcoholics though incapable of sustaining a cognitive set were intact in the capacity of error util-

ization. The long-term alcoholics were impaired in both of these aspects of cognitive functioning. "Learning to learn," described as the rate of improvement across successive sets, was not different between the groups. The deficits where they were manifest cannot be attributed simply to an impairment of abstracting ability or conceptual capacity per se, as no discrepancy between the groups was noted in the ability to identify simple concepts as illustrated by their performance on the first set.

CHAPTER IV

EXPERIMENT II: SET SHIFTING CAPACITY OF CHRONIC ALCOHOLICS

Alcoholics have been demonstrated to perform at a level inferior to controls on the Wisconsin Card Sorting Test (Tarter and Parsons, 1971). This deficit was subsequently found in Experiment I to be extant in only those individuals who admitted to being an alcoholic for more than ten years. Subjects with an alcoholism history of less than ten years were not different from controls on the trials and errors measures.

One aspect of cognitive functioning which has as yet not been adequately evaluated concerns the ability of alcoholics to shift cognitive sets. Previous investigations (Tarter and Parsons, 1971; Experiment I) have not provided a clear answer to this problem since in the paradigm employed the inability of the alcoholics (particularly the long-term alcoholics) to maintain a cognitive set may have adventitiously interacted with the ability to switch sets. For example, it was reported in Experiment I that the alcoholics tended to interrupt a correct sequence of responses with an error more than controls. One of the direct consequences of such interruptions is that the alcoholics received a greater number of sequential positive reinforcements than the controls. Thus while the controls by and large received only the ten consecutive positive reinforcements, these being the criterion responses; the alco-

holics in addition had more sequences of responses than the controls that were positively reinforced, but were subsequently interrupted with an error. It follows then that (since the strength of a response is positively correlated with the number of reinforcements) the alcoholics by virtue of the fact that they adventitiously received more sequences of positive reinforcements would be more reluctant to abandon the cognitive set after the shift was introduced. Indeed, this was the case for the long-term alcoholics, who emitted significantly more perseverative errors than the controls and short-term alcoholics within the first ten trials after a set change while the latter two groups did not differ from each other. Thus the number of response sequence interruptions may be tied to or at least confounding of the ability to shift sets.

The present experiment was designed to evaluate set shifting capacity of alcoholics in a paradigm that was free from any possible contaminating effects of set impersistence.

Method

Subjects

Thirty alcoholic patients volunteered to participate in this study. All were inpatients of a ninety-day treatment program that was designed specifically for the rehabilitation of chronic alcohol abuse. During their stay in the hospital they participated in psychotherapy as well as industrial, physical and occupational therapy. In addtion, each patient received a balanced diet that was supplemented with daily doses of vitamins.

The alcoholics were divided on the basis of the duration of al-

coholism history into two groups of fifteen subjects each. The first group admitted to being an alcoholic for ten years or less, while the other group described themselves as being an alcoholic for a period in excess of ten years. As reported in Experiment I, this dichotomy is not based on any theoretical presupposition but is utilized insofar as it enables the two groups of alcoholics to be equated for age but yet have differing durations of alcoholism histories. The former group shall for convenience be called the short-term alcoholics. They had a mean alcoholism history of 2.4 years. The latter group shall be referred to as the long-term alcoholics, and they had a mean alcoholism history of 15.8 years. Testing was commenced after at least one month had elapsed from when they entered the program so that the effects of acute alcohol withdrawal could subside. None of the alcoholics had ever suffered from an acute neurological disease to the central nervous system or had a history of psychosis.

Fifteen controls, also inpatients at the V.A. Hospital, were volunteers from the general medicine wards. No patient was included in this group who had a alcoholic, psychiatric or neurological history.

All of the subjects were administered the Shipley-Hartford Institute of Living Scale. This test yields information which describes the individual's verbal age, abstracting age and conceptual quotient (a measure of intellectual deterioration). In addition, the obtained total raw score can be converted into the WAIS equivalent full scale IQ (Paulson and Lin, 1970).

In Table 8 are presented the means and standard deviations for each group on the variables of age, education, Shipley-Hartford Test

TABLE 8

MEANS AND STANDARD DEVIATIONS FOR AGE, EDUCATION, SHIPLEY-HARTFORD SCORES AND WAIS EQUIVALENT IQ

Variable	Controls		Short-term Alcoholics		Long-term Alcoholics	
	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Age	44.8	7.6	45.3	11.7	46.3	4.6
Education	11.3	2.7	11.7	3.2	11.3	3.2
Verbal Age	16.0	1.6	16.7	2.1	16.6	2.4
Abstract Age	13.4	2.3	13.7	2.9	13.4	3.3
CQ	83.9	13.7	84.3	17.2	82.3	15.6
WAIS IQ	104.4	9.1	106.7	12.1	104.9	12.5

scores and WAIS IQ. Comparisons between the groups on each of these variables did not reveal any significant differences. It is of interest to note that the subjects employed in this investigation are comparable on these variables with the subjects utilized in the first experiment.

Procedure

The same instructions for the Wisconsin Card Sorting Test were administered in this experiment as in the first investigation, although the actual testing procedure was somewhat different. Instead of utilizing a criterion of ten consecutive correct responses before the set was switched, the shift was introduced after three successive correct trials. In this way the occurrence of sequence interruptions, defined as five or more consecutively correct responses that are followed by an error, are prevented.

The subjects learned the first seven concepts in the order of color, form number, etc., to the criterion of three successive correct responses. Then, without informing the subject or introducing any form of delay in the task, three additional sets were learned to the criterion of ten consecutive correct trials. The reason the last three sets were administered in the same procedure as Experiment I was to attempt a replication of those results. If that could be achieved despite the fact that the prior seven sets were learned under different conditions, in addition to the fact that only three sets were used, then it can be concluded that the sample of subjects tested in this investigation was drawn from the same population as those who participated in the first experiment. However, if on the other hand, the results of the present study do not confirm the findings of Experiment I, it would be difficult

to draw a conclusion as to the source of the failure to replicate, since it could be due either to the effects of the first seven sets influencing performance on the subsequent three sets or be due to a sampling bias.

Results

Seven indices of performance were recorded. They were the following: 1) trials to criterion, 2) total errors per set which was broken down into 3) perseverative and 4) 'other' errors. A perseverative error was defined as a response that is incorrect on the current set but was correct on the immediately preceding set. An 'other' error was defined as any incorrect response that was not perseverative. Since by definition perseverative and 'other' errors could not occur on the first set, they were computed from set two onward. The fifth index of performance was the number of perseverative errors emitted within the first ten trials after a set change.

The number of spatial perseverations was also recorded; that is, the frequency of times that successive incorrect responses were made to the same stimulus card of the four possible alternatives. Because it would be expected that the number of such errors would increase on a chance basis alone as the number of total errors increased, and since the number of total errors varied between individuals; the number of spatial perseverations was divided by the total number of errors and the resulting quotient multiplied by one-hundred to yield the percent spatial perseverations.

The rate of sorting comprised the seventh dependent variable. The number of responses per minute was tabulated for each subject and the means and standard deviations derived for each group.

Except for the last two measures, the first seven sets were analyzed independently of the last three sets. The analyses were carried out in this way since the criterion level of performance differed between these two segments of the task. The indices of spatial perseverations and response rates are unrelated to the criterion level and so these measures were computed into a single score based on all ten sets.

The data for the first four measures were transformed by the formula $y = \sqrt{x + 1}$ to reduce the effects of extremely deviating scores (Bartlett, 1936). The square root transformation has formerly been recommended for use in Wisconsin Card Sorting Test data (Grant and Cost, 1954). No transformation was employed on the scores describing the number of perseverative errors emitted within the first ten trials after a set switch. Since the range of scores was fixed between 0-10, extreme scores were therefore not possible. The spatial perseverations and rate of sorting measures were not subjected to the square root transformation since they already were transformed; the former measure into a percentage score and the latter into a ratio score (responses/minute).

In Figures 7 and 8 are illustrated the performance curves for each group on the trials and total errors measures. The indices of perseverative and 'other' errors exhibit the same pattern of performance across sets and the means are presented in Table 9. Analyses of variance were computed and the resulting F-ratios are summarized in Tables 10 and 11. Note that on the first seven sets, none of the F-ratios on any measure for the Groups effect were significant. Neither was the Groups x Sets interaction significant for any index of performance. The only significant effect was for sets, indicating a general decline in

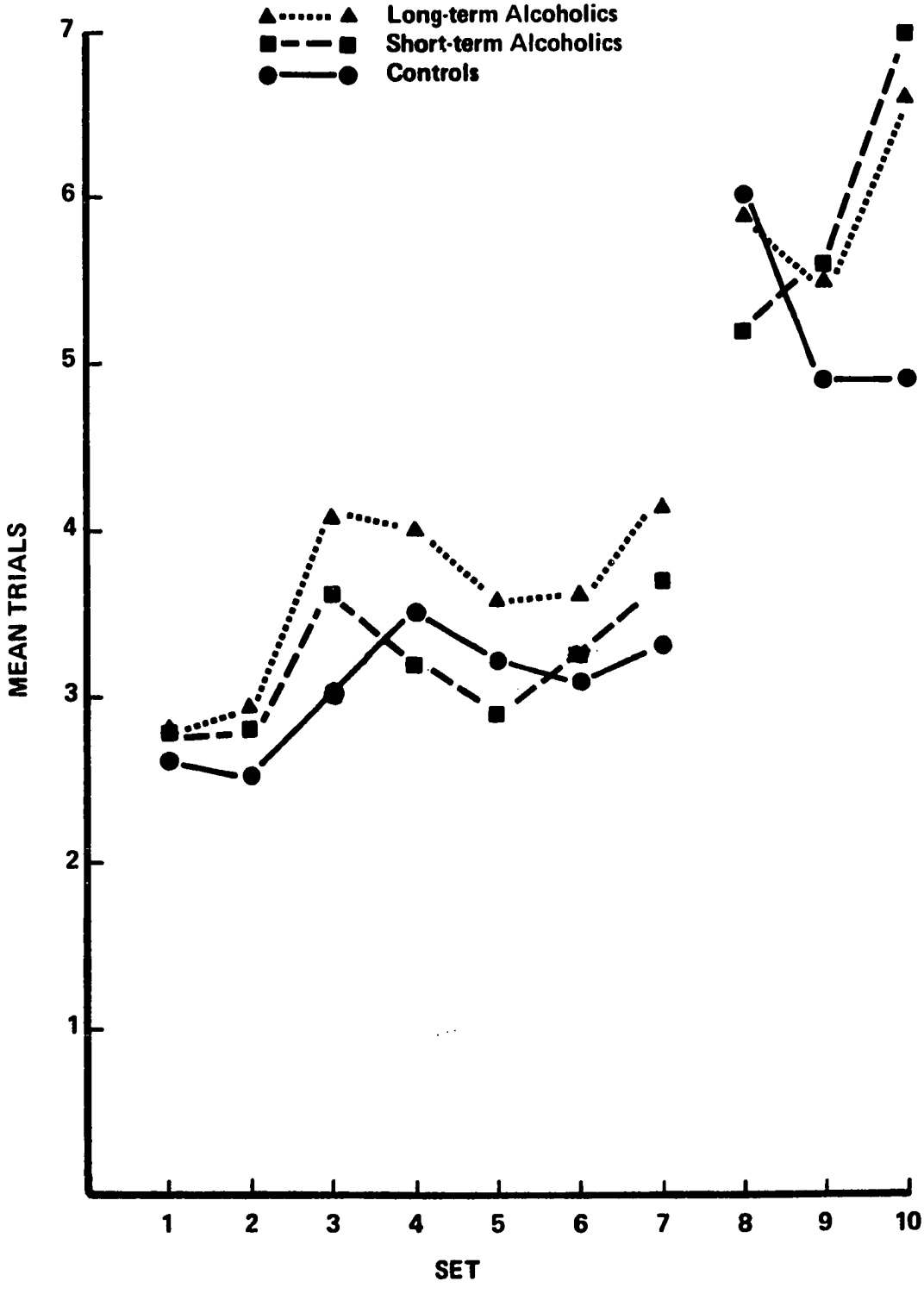

Figure 7. Mean trials to criterion.

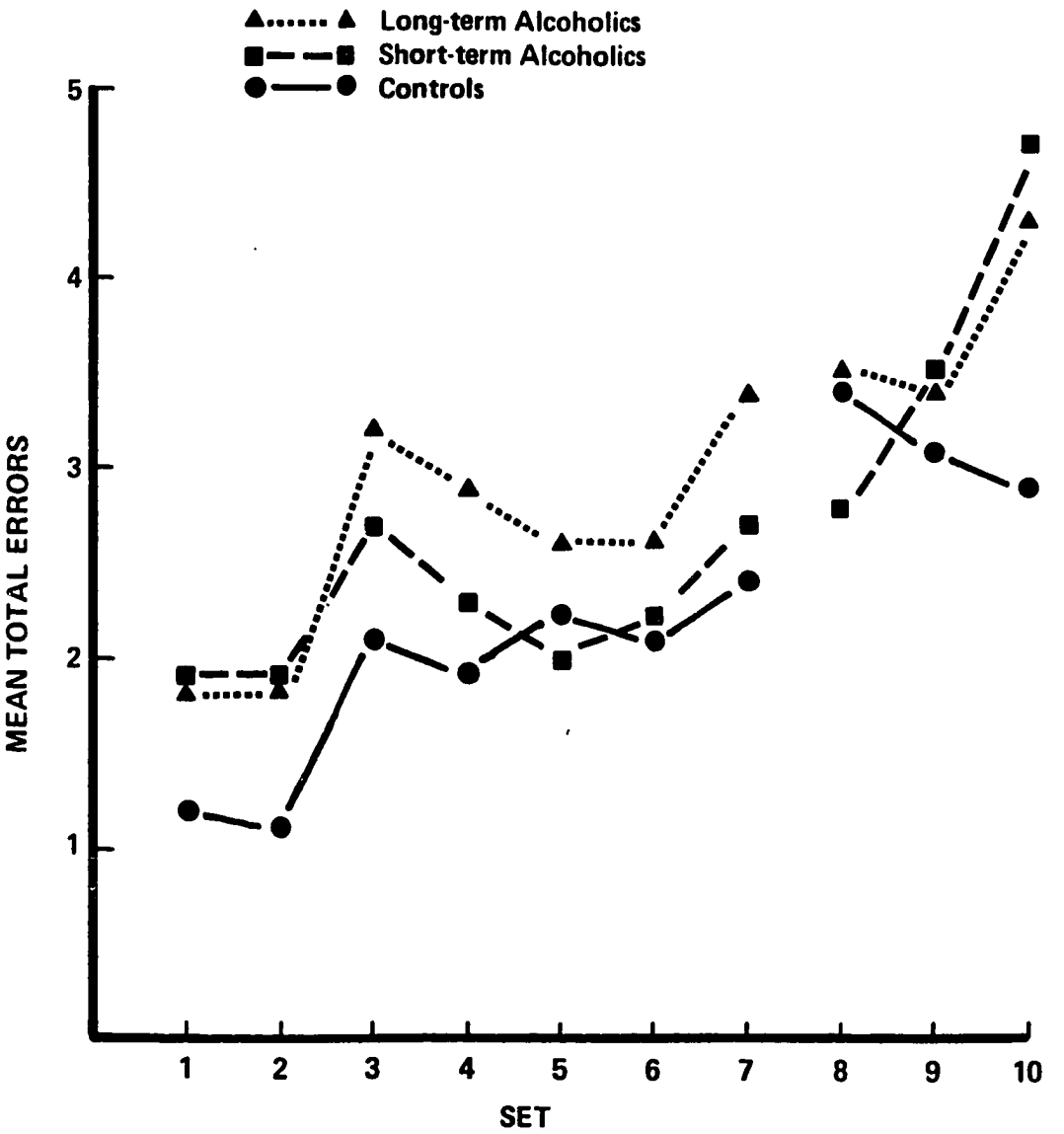

Figure 8. Mean total errors.

TABLE 9

MEAN SCORES FOR EACH GROUP ON THE MEASURES OF PERSEVERATIVE ERRORS, 'OTHER' ERRORS AND PERSEVERATIVE ERRORS EMITTED WITHIN THE FIRST 10 TRIALS AFTER A SET SHIFT

	Set								
	2	3	4	5	6	7	8	9	10
Perseverative Errors[a]									
Controls	1.488	1.890	2.138	1.879	1.852	2.125	2.539	2.715	2.455
Short-term Alcoholics	1.834	2.376	1.940	1.602	2.025	2.318	2.405	2.255	3.959
Long-term Alcoholics	1.772	2.739	2.450	2.116	2.226	2.978	2.856	2.972	3.646
'Other' Errors[a]									
Controls	1.280	1.430	1.810	1.590	1.517	1.576	2.483	1.780	1.892
Short-term Alcoholics	1.146	1.700	1.586	1.626	1.480	1.860	1.784	1.783	2.882
Long-term Alcoholics	1.286	2.053	1.966	2.260	1.820	2.000	2.313	2.097	2.613
Perseverative Errors Emitted within the First 10 Trials After a Set Shift[b]									
Controls	1.333	2.266	2.533	2.133	1.800	3.000	2.600	4.266	2.933
Short-term Alcoholics	1.733	3.333	2.600	1.666	2.800	3.000	2.333	4.400	4.600
Long-term Alcoholics	2.333	3.400	3.133	2.600	2.733	4.266	3.333	4.200	3.866

[a]Based on square root transformed data.

[b]Based on raw data.

TABLE 10

SUMMARY OF ANALYSES OF VARIANCE BETWEEN ALL THREE GROUPS FOR EACH MEASURE ON SETS 1-7

Source	df	MS	F	p <	(p <)[a]
Trials					
Groups	2	8.055	2.337	ns	(ns)
Sets	6	6.311	4.391	.01	(.05)
G x S	12	1.443	1.004	ns	(ns)
Total Errors					
Groups	2	8.252	2.644	ns	(ns)
Sets	6	7.647	6.147	.01	(.05)
G x S	12	0.777	0.624	ns	(ns)
Perseverative Errors					
Groups	2	5.703	2.965	ns	(ns)
Sets	5	3.968	4.483	.01	(.05)
G x S	10	0.545	0.615	ns	(ns)
'Other' Errors					
Groups	2	3.689	2.208	ns	(ns)
Sets	5	2.288	3.732	.01	(.10)
G x S	10	0.361	0.588	ns	(ns)
Perseverative Errors within 10 Trials After a Set Shift					
Groups	2	18.560	2.922	ns	(ns)
Sets	5	15.670	3.869	.01	(.10)
G x S	10	1.780	0.439	ns	(ns)

[a]Conservative probability estimates for within-subject effects (Winer, 1962, pp. 305-306). Derived by assigning one degree of freedom to the replicated measure; in this case sets. Thus Sets has 1 df and Groups x Sets has 2 df.

TABLE 11

SUMMARY OF ANALYSES OF VARIANCE BETWEEN ALL THREE GROUPS FOR EACH MEASURE ON SETS 8-10

Source	df	MS	F	p <	(p <)[a]
Trials					
Groups	2	8.439	1.274	ns	(ns)
Sets	2	7.803	3.376	.05	(.10)
G x S	4	9.201	3.981	.01	(.05)
Total Errors					
Groups	2	5.775	1.258	ns	(ns)
Sets	2	7.192	4.077	.05	(.05)
G x S	4	5.602	3.175	.05	(.05)
Perseverative Errors					
Groups	2	5.652	1.848	ns	(ns)
Sets	2	6.391	5.453	.01	(.05)
G x S	4	2.840	2.425	ns	(ns)
'Other' Errors					
Groups	2	1.688	0.597	ns	(ns)
Sets	2	3.735	5.995	.01	(.05)
G x S	4	2.722	4.369	.01	(.05)
Perseverative Errors within 10 Trials After a Set Shift					
Groups	2	4.085	0.654	ns	(ns)
Sets	2	27.600	8.726	.01	(.01)
G x S	4	5.210	1.647	ns	(ns)

[a]Conservative probability estimates in which Sets has 1 df and Groups x Sets has 2 df.

performance across sets. The decrement in performance across the first seven sets however cannot be attributed to motivational factors, since all of the groups performed at better than chance level. The probability of obtaining three consecutive correct responses in a four choice situation is $(1/4)^3$ or 1/64. It is therefore to be expected that the subject would attain criterion in sixty-four trials if he was card sorting on a random basis alone. It can be observed in Figure 7, where the square root transformed results are presented, that all three groups performed significantly better than chance level (chance = $\sqrt{64 + 1}$).

The analyses of variance for sets 8-10 revealed a different picture. Though as before, the main effect for Groups was not significant, it was observed that a significant Groups x Sets interaction occurred on three of five measures. From Table 9 and Figures 7 and 8, it can be seen that the controls demonstrated an improvement across the last three sets while the alcoholics exhibited a deterioration of performance.

Because none of the main effects for Groups were significant, it was decided to combine the two alcoholic groups. This manipulation was employed to determine if an alcoholism history, regardless of duration, differentiated them from controls. The data were then resubmitted to analyses of variance. The F-ratios are summarized in Tables 12 and 13. Again as before, the same relationships between the groups are observed on sets 1-7. None of the measures for the Groups effect were significant. The Sets effect was significant indicating as before, that the groups exhibited a decrement in performance across sets. The Groups x Sets interactions were not significant demonstrating that the performance of the two groups across sets was essentially in parallel.

TABLE 12

SUMMARY OF ANALYSES OF VARIANCE BETWEEN THE CONTROLS AND THE COMBINED GROUP OF ALCOHOLICS ON EACH MEASURE FOR SETS 1-7

Source	df	MS	F	p <	(p <)[a]
Trials					
Groups	1	7.114	2.762	ns	(ns)
Sets	6	11.992	44.746	.01	(.01)
G x S	6	0.584	2.179	ns	(ns)
Total Errors					
Groups	1	8.095	2.493	ns	(ns)
Sets	6	7.674	6.206	.01	(.05)
G x S	6	0.854	0.693	ns	(ns)
Perseverative Errors					
Groups	1	2.036	2.690	ns	(ns)
Sets	5	3.968	4.524	.01	(.05)
G x S	5	0.518	0.590	ns	(ns)
'Other' Errors					
Groups	1	2.437	1.394	ns	(ns)
Sets	5	2.288	4.252	.01	(.05)
G x S	5	0.474	0.881	ns	(ns)
Perseverative Errors within 10 Trials After a Set Shift					
Groups	1	23.230	3.559	ns	(ns)
Sets	5	15.670	3.604	.01	(.10)
G x S	5	1.650	0.377	ns	(ns)

[a]Conservative probability estimates in which Sets has 1 df and Groups x Sets has 1 df.

TABLE 13

SUMMARY OF ANALYSES OF VARIANCE BETWEEN THE CONTROLS AND THE COMBINED GROUP OF ALCOHOLICS ON EACH MEASURE FOR SETS 8-10

Source	df	MS	F	p <	(p <)[a]
Trials					
Groups	1	16.849	2.604	ns	(ns)
Sets	2	7.803	3.362	.05	(.10)
G x S	2	15.520	6.681	.01	(.05)
Total Errors					
Groups	1	11.405	2.542	ns	(ns)
Sets	2	7.192	4.040	.05	(.05)
G x S	2	8.713	4.894	.05	(.05)
Perseverative Errors					
Groups	1	11.253	3.767	ns	(ns)
Sets	2	6.391	5.425	.01	(.05)
G x S	2	4.282	3.634	.05	(ns)
'Other' Errors					
Groups	1	1.126	0.675	ns	(ns)
Sets	2	3.735	5.863	.01	(.05)
G x S	2	4.217	6.620	.01	(.05)
Perseverative Errors within 10 Trials After a Set Shift					
Groups	1	8.182	1.342	ns	(ns)
Sets	2	27.600	15.106	.01	(.01)
G x S	2	14.643	8.014	.01	(.01)

[a]Conservative probability estimates in which Sets has 1 df and Groups x Sets has 1 df.

The analyses of variance on sets 8-10 did not reveal a significant main effect for Groups on any measure. The Groups x Sets interaction was however significant.

The short- and long-term alcoholics committed more spatial perseverations than the controls but the former two groups did not differ from each other. These differences were significant beyond the .05 level as determined by the Neuman-Keuls Test. In Table 14 the analysis of variance is summarized indicating the significant main effect for Groups. Though the absolute magnitudes of the percent spatial perseverations as a function of the total number of errors is small, being 7.59 percent, 10.81 percent and 11.84 percent in the controls, short- and long-term alcoholics respectively, it is nonetheless concluded that alcoholics exhibit a greater tendency than controls to manifest such an error.

TABLE 14

SUMMARY OF ANALYSIS OF VARIANCE ON SPATIAL PERSEVERATIONS

Source	df	MS	F	p <
Groups	2	73.56	4.46	.05
Error	42	16.49		
Total	44			

In Table 15 the means and standard deviations describing the rate of responding for each group are presented. The rate of sorting was faster in the long-term alcoholics than controls ($\underline{t}$ = 2.289, df 28, $p < .05$) but not the short-term alcoholics ($\underline{t}$ = 1.391, df 28, ns). The

controls did not perform differently from the short-term alcoholics (t = 0.985, df 25, ns). The rate of responding was found to be negatively correlated with the number of set interruptions in the long-term alcoholics (r = -0.55, df 13, $p < .05$) but not in the short-term alcoholics (r = -0.20, df 13, ns) or controls (r = -0.06, df 13, ns). Hence within the long-term alcoholic group, the faster the subjects sorted the less interruptions they manifested, suggesting that the increased rate of performance was beneficial to the subject. Thus it is concluded that an alcoholism history in excess of ten years results in an accelerated mode of responding, but this appears to have an adaptive function (at least on the Wisconsin Card Sorting Test) in that performance is better the faster the rate of sorting.

TABLE 15

MEANS AND STANDARD DEVIATIONS OF RATE OF RESPONDING (CARD SORTS PER MINUTE) FOR EACH GROUP

Group	$\bar{X}$	s
Controls	5.4	1.7
Short-term Alcoholics	6.3	2.8
Long-term Alcoholics	8.2	4.1

One puzzling result of this investigation was the apparent failure to replicate on sets 8-10 the findings of the first experiment. As previously discussed, no significant Groups effect was observed, and also contrary to the results of Experiment I was the observation of a significant Groups x Sets interaction in the present study. Furthermore,

the groups were not differentiated on the number of response sequence interruptions. The controls manifested a set interruption (defined as five or more correct responses that are followed by an error) on 37.7 percent of the sets while the short- and long-term alcoholics committed an interruption on 62.2 percent and 68.8 percent of the sets. Upon computation of *t*-tests, it was found that the controls did not perform significantly differently from the short-term (t = 0.981, df 28, ns) and long-term alcoholics (t = 1.509, df 28, ns). Nor did the two alcoholics differ from each other (t = 0.275, df 28, ns). Even after the two alcoholic groups were combined, no significant differences were observed (t = 1.441, df 28, ns). Mann-Whitney U tests were also calculated and again it was observed that the three groups did not significantly differ from each other.

Thus with respect to the capacity of set persistence, the results of this experiment do not replicate those of Experiment I. The possible reasons for this are discussed in the next section of this report.

Discussion

The results of this investigation demonstrate that alcoholics do not suffer from an impairment in switching cognitive sets when the criterion level is three consecutive correct responses and the adventitious effects from reinforced but interrupted response sequences are eliminated. Neither the short- nor long-term alcoholics performed significantly more poorly than the controls. Moreover, the two combined groups of alcoholics did not perform differentially from the controls.

The failure to replicate on sets 8-10 the results of the first

experiment may be due to several factors. The first possibility may be a function of sampling variables. However, since all of the subjects in both experiments were inpatients at the same hospital and lived in the same geographic region, the likelihood of a sampling bias is very small. Furthermore, the variables of age, education and intelligence are very similar in both experiments. It is thus concluded that the failure of this experiment to replicate the results of the first experiment is not attributable to sampling factors.

One reason why the groups were not differentiated on the percent of set interruptions may be due to the fact that only three sets were administered in the present investigation, while in the first experiment the subjects were allotted up to eighteen sets. Even though the differences between the groups were not statistically significant, they did perform in the expected direction. It is probable therefore that if more sets were administered, significant group differences would have emerged.

It is also of interest to note the significant Groups x Sets interaction on sets 8-10. The exact reason for this is unclear but the hypothesis is tentatively advanced that the alcoholics were differentially affected by the first seven sets more than the controls. The fact that the set was changed after three consecutive correct choices is speculated here to result in a subjective attitude of failure for each individual. It is postulated that because the set was changed before the subject's hypothesis testing could be adequately confirmed over a succession of trials, the subject never feels that he is mastering the task. When the level of difficulty is lowered by changing the criterion for successful performance from three to ten consecutively correct responses, the con-

trols exhibit an improvement across the remaining three sets while the alcoholics continue to manifest an increasing decrement. The essence of the hypothesis advanced here is that the experience of subjective failure on the first seven sets resulted in a resigned attitude of task incompetence in all subjects; but when the criterion was changed to ten successive correct responses the controls were able to adjust and improve while the alcoholics were still affected by the experience of failure and continued to deteriorate in performance.

Support for this hypothesis is derived from several sources. First, it has already been established that the criterion of three consecutive correct responses is a more difficult criterion than ten successive correct choices (Grant and Berg, 1948). In the present investigation, it could be observed that both groups exhibited a general deterioration of performance across the first seven sets. This is statistically represented by the significant F-ratios on most of the measures for the sets effect. Thus, this part of the task is in fact more difficult than the usual procedure of changing sets after ten correct choices as has been previously demonstrated in a sample of college students (Grant and Berg, 1948) and as is reflected by the general decline in performance efficacy in all groups of the present study.

A second point which deserves mention in this regard is that many of the subjects verbalized some apprehensiveness about the task. Often after several set shifts had already been enacted, they would verbalize to the experimenter that they did not know what was wanted or expected from them. On many occasions the subjects spontaneously stated that just when they thought they had the idea, the experimenter would

say "wrong." In fact, two alcoholics for whom testing was in progress insisted on quitting, claiming they didn't know what was going on and hence couldn't do the task. This was the first investigation that such events have occurred with this experimenter, who personally has administered individual psychological and performance tests to about one-hundred and fifty alcoholics. The point to be made however, is that though the subjects were motivated, they were also confused and distressed during their performance, and it is conjectured here that this affected the performance of the alcoholics on the last three sets more than it did the controls.

That prior failure can influence subsequent performance has already been demonstrated in a psychopathological sample on a concept identification task. Pishkin, Shurley and Wolfgang (1967) have reported that prior failure disrupted subsequent performance in a group of schizophrenics more than controls. Perhaps the same holds true for chronic alcoholics.

Two positive results were obtained in this investigation. First it was observed that alcoholics tended to manifest more spatial perseverations than controls. This error type has been documented on many occasions (cf. Warren and Akert, 1964) to be characteristic of animals with prefrontal lesions.

Another finding of this experiment was that the long-term alcoholics sorted at a faster rate than the other two groups. The precise meaning of this is as yet unclear but may reflect a loss of inhibition, or conversely an increase in impulsivity as has been observed in chronic alcoholics by Edelberg (1970). An accelerated mode of motoric responding

would be expected to result in an increment in the rate of card sorting in the long-term alcoholics.

In conclusion, this investigation has demonstrated that alcoholics are not impaired at shifting cognitive sets when the criterion is three consecutive correct responses. This is indicated by the failure of the Wisconsin Card Sorting Test to discriminate between the groups on the first seven sets. The observation that the controls exhibited an improvement in performance on the last three sets while the alcoholics deteriorated is hypothesized to be due to the differential effect that prior failure had on subsequent performance in each group. The thesis was tentatively advanced that alcoholics are more susceptible to the effects of failure on subsequent performance than are normal controls. Two results which did differentiate the groups were that the long-term alcoholics sorted at a faster rate than the other two groups, and that both groups of alcoholics manifested more spatial perseverations than the controls. It was speculated that the former mode of problem solving reflected a decrease in inhibitory capacity or increment in behavioral impulsivity. The spatial perseverations were hypothesized to reflect an organic deficit, presumably to the prefrontal cortex. A comprehensive discussion on the plausability of postulating a prefrontal focus of neurological deficit is presented in Chapter VI, the General Discussion section of this manuscript.

CHAPTER V

EXPERIMENT III: NEUROPSYCHOLOGICAL CONCOMITANTS OF CHRONIC ALCOHOLISM

There is evidence from both the neurological and psychological literature which implicate a cerebral dysfunction in chronic alcoholics. Electroencephalographic and pneumoencephalographic studies have been conducted with the typical finding of a cerebral impairment, particularly in the frontal regions of the brain (Lereboullet, and Pluvinage, 1956; Lereboullet et al., 1956; Tumarkin, Wilson and Snyder, 1955). Examination of the brains of autopsized alcoholics has also revealed that there are pathological alterations in the frontal and frontal-limbic areas (Alexander, 1941; Courville, 1955; Creutzfeldt, 1928).

As yet no systematic attempt has been made to specify the most probable site of the brain dysfunction from psychological data. The literature that was reviewed in Chapter I strongly implicates an organic impairment which is not manifested as a global reduction of all intellectual and cognitive capacities. Rather the deficits appear to be relatively specific (Jones and Parsons, 1970), suggesting that the neurological focus might also be circumscribed.

The frontal regions of the brain as noted above appear to be very susceptible to disruption from chronic alcohol abuse. However, there is a notable absence of behavioral evidence to substantiate the

neurological findings. Since many of the characteristic deficits of frontally lesioned animals and humans are being studied in the present investigation (e.g., "learning to learn," perseverative response tendencies, set shifting capacity, error utilization and temporal response sequencing), it was decided to administer several additional tests that measure capacities not related specifically to conceptual ability but which have been shown to produce impaired performance in frontally damaged individuals. In so doing, it was hypothesized that if alcoholics do in fact suffer from a neurological deficit to the anterior regions of the brain, then they would manifest an impairment on these tests similar to that seen in patients with lesions in that area.

The tests measure perceptual, spatial and attentional capacities. Apart from their neuropsychological implications, it is proposed that the instruments may also have value in elucidating the nature of the behavioral deficits at the psychological level of analysis.

The first test administered was the Maze Tracing Speed Test. The test is identified by the factor labelled Spatial Scanning (French, Ekstrom and Price, 1963) and measures the ability to visually transverse a complex spatial field. To a certain extent, this instrument also measures the capacity to plan a set of actions prior to their execution. An impairment on maze tasks has been observed in prefrontally damaged patients (Milner, 1964; Porteus, 1959) while a transitory deficit has been reported in alcoholics by Jonsson et al. (1962). Fitzhugh et al. (1960, 1965) and Goldstein and Chotlos (1965) observed that alcoholics were impaired on the Trail Making Test, a modified version of the traditional Maze test.

The Maze Tracing Speed Test was adopted from the Kit of Reference Tests for Cognitive Factors (French et al., 1963). The test is factorially pure and can be administered to individuals with a wide range of educational levels. A copy is attached in the Appendix.

The second instrument administered was the Goal Directed Serial Alternation Test. This test was adapted from that described by Melges, Tinklenberg, Hollister and Gillespe (1970) who found impaired performance in subjects under acute marihuana intoxication. On this test the subject must commence at a specified number and perform in alternation the sequential arithmetical operations of subtraction and addition until a predetermined goal is reached. A variant of this test in which the subject must perform only successive subtractions has been shown to be sensitive in detecting frontal lobe dysfunction (Luria, 1966). Because an impairment, if any, in alcoholics is not expected to be as severe as that which is seen in acute neurological cases, the more complex form of the test, namely the procedure described by Melges et al. (1970) was preferred over that of Luria's (1966). Various indices of performance can be derived, including speed of performance, arithmetic errors, attentional lapses, alternation errors and whether or not the subject can remember to terminate performance once the goal is achieved.

The third and last test utilized was the Copying Test. This instrument is part of the Kit of Reference Tests for Cognitive Factors (French et al., 1963) and is identified by the factor called Flexibility of Closure. As such, it measures the capacity to "keep one or more definite configurations in mind so as to make identification in spite of perceptual distractions" (French et al., 1963). The subject is required

to reproduce a sample geometric figure on a matrix of dots. A copy of this test is attached in the Appendix.

Because this dimension of cognitive functioning is related to Witkin's field orientation construct as measured by the rod and frame test (French et al., 1963), it was postulated that if alcoholics are field-dependent they would perform more poorly than controls on this test. However, it is acknowledged that this is a weak effort to identify field-dependency, since the fact that the tests measuring field orientation and flexibility of closure are correlated does not necessarily mean that they are interchangeable. Because the field-dependent mode of perceptual functioning is characteristic of individuals with prefrontal damage as judged by the rod and frame test (Teuber, 1964), it was felt that if alcoholics were also impaired on Copying Test it would implicate such a deficit in analytical perceptual capacity, and the anterior region of the brain as the neuropathological focus.

Method

Subjects

The same 45 subjects who participated in Experiment II also participated in the present investigation. They were administered the following tests immediately after completion of the Wisconsin Card Sorting Test.

Procedure

The Maze Tracing Speed Test and Copying Test were administered in the standardized procedure. Each test consists of two parts, each

timed for three minutes. The Maze Test was administered first, and the number of boxes that the individual successfully completed was the assigned score. If the rules of the task were violated, that is, if the subject transversed the line of a blind alley rather than maneuver around it, he was not given credit for that box. This, however, happened only three times, in each instance by a short-term alcoholic.

The Goal Directed Serial Alternation Test was administered second. The subject was instructed to commence at the number 110 and then subtract 7 and add 2 in alternating fashion until the number of 60 was reached. Each of the arithmetical operations was pronounced aloud and recorded on tape for later scoring. The total number of operations was 20, of which 10 were addition and 10 were subtraction.

The instructions administered were as follows: "I want you to begin at the number 110 and from that number subtract 7 to get a number, then add 2 to get a number and thereafter continue to subtract 7 and add 2 in alternation until you reach 60. Say each calculation out loud. Try to do this as rapidly as you can, but also be as accurate as possible. Do you know what to do? Okay then - begin!" The measures recorded were: 1) time, 2) arithmetic errors in calculation, 3) alternation errors; that is, the subject performed the wrong type of operation, subtracting instead of adding or vice versa, 4) loss of place, operationally defined as either an attentional lapse of five seconds or longer followed by an incorrect response, or by an incorrect response that exceeded the correct answer by plus or minus ten points. In either case, the erroneous response was postulated to be due to the subject losing his place. And the fifth measure recorded was the number of subjects

who either forgot or disregarded the goal, identified by the subject's continuance of the task after the number 60 had been reached. With the exception of the fifth index, each of these measures were tabulated for the first half, second half and then combined for the full length of the test.

If the subject manifested an error, the correct response was provided by the experimenter. Similarly, if a pause in excess of five seconds occurred, the experimenter interrupted the silence with the correct answer.

The Copying Test was then administered. The number of items attempted and the number of correct responses were recorded for each part of the test. The scores for the two parts combined were also determined. These latter scores were then converted into the percent of correct responses, obtained by dividing the number of right answers by the number of items attempted and the resulting quotient multiplied by 100.

Results

Maze Tracing Speed Test

The means and standard deviations on the number of boxes completed are presented in Table 16 for the Maze Tracing Speed Test. It can be noted that the long-term alcoholics performed slightly better than the short-term alcoholics, but this was due directly to one subject who obtained a total score of 22 - three standard deviations above that of the mean of the group. It was therefore decided to discard this subject from subsequent analyses (on this test only) so as to enable a more homogeneous description of the group's performance. The means and standard

deviations for the long-term alcoholics based on fourteen subjects are presented in Table 17.

TABLE 16

MEANS AND STANDARD DEVIATIONS FOR EACH GROUP ON THE MAZE TRACING SPEED TEST

Group	Part I		Part II		Total	
	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Controls	7.2	1.4	9.3	2.2	16.5	3.1
Short-term Alcoholics	5.8	1.8	7.7	2.5	13.5	4.2
Long-term Alcoholics	6.2	1.8	8.2	2.2	14.4	3.9

TABLE 17

MEANS AND STANDARD DEVIATIONS FOR THE FOURTEEN LONG-TERM ALCOHOLICS ON THE MAZE TRACING SPEED TEST

	Part I	Part II	Total
$\bar{X}$	5.9	7.7	13.6
s	1.4	1.4	2.6

It is apparent from inspection of Tables 16 and 17 that the long-term alcoholics do not differ from the short-term alcoholics, in fact they perform almost identically to the latter group. The two groups were thus combined into one (n = 29) and compared to the controls by means of *t*-tests. The controls completed significantly more boxes than

the alcoholics on part one (t = 2.732, df 42, $p < .01$) and part two (t = 2.351, df 42, $p < .05$). The controls similarly completed more total boxes than the alcoholics (t = 2.797, df 42, $p < .01$). On the basis of these results it is concluded that alcoholism is detrimental to performance on the Maze Tracing Speed Test, implicating an impairment in spatial scanning and planning ability. However, no difference was noted between the short- and long-term alcoholics, suggesting that the duration of the alcoholic history is not of critical importance, but rather an alcoholism history *per se*, even of limited duration results in an impairment in these functions.

Goal Directed Serial Alternation Test

No discrepancies between the groups were found on any measure of the Goal Directed Serial Alternation Test. In Table 18 are presented the means and standard deviations of the time scores for the first half and second half of the task as well as the total time for the two halves combined. Analyses of variance were conducted on the time scores, yielding nonsignificant F-ratios for the first part (F = 1.909, df 2/42, ns), second part (F = 1.644, df 2/42, ns) and total time (F = 1.776, df 2/42, ns). Because, as can be seen in Table 18, there was greater variability of performance in the alcoholic groups than the controls, it was hypothesized that perhaps the magnitude of the variability (particularly in the long-term alcoholics) was preventing the significant effect to emerge. To examine this possibility, the Kruskall-Wallis test, a nonparametric statistic was applied to the total time scores. Again no differences were noted (H = 1.847, df 2, ns) indicating that the variability of performance in the alcoholics cannot explain the absence of the significant

difference. It was also speculated that the long-term alcoholics might differ from the other two groups with respect to their "central tendency" of performance. The median test was subsequently computed and it was found that the long-term alcoholics did not differ from the controls (x^2 = 0.533, df 1, ns) and short-term alcoholics (x^2 = 0.533, df 1, ns). It is therefore concluded that the somewhat higher mean scores of the long-term alcoholics are due to several individuals performing exceptionally poorly. The medians test was not calculated between the controls and short-term alcoholics as it is obvious that they do not differ from each other. Thus the medians test, a statistic describing the degree to which groups correspond in their central tendency or typical level of performance, did not discriminate between the groups.

TABLE 18

MEANS AND STANDARD DEVIATIONS FOR THE THREE GROUPS ON THE TIME MEASURE OF THE GOAL DIRECTED SERIAL ALTERNATION TEST

Group	First Half		Second Half		Total	
	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Controls	41.7	20.2	41.7	17.0	83.5	35.6
Short-term Alcoholics	41.1	21.3	43.2	24.3	84.3	44.7
Long-term Alcoholics	58.1	34.5	56.1	27.0	114.3	60.7

The groups were not differentiated in the number of arithmetic errors. In Table 19 are summarized the means and standard deviations as well as the number of subjects within each group who committed one or

more errors. No statistical tests were computed as it is obvious that no differences exist between the three groups.

TABLE 19

MEANS AND STANDARD DEVIATIONS ON THE NUMBER OF ARITHMETIC ERRORS, AND THE NUMBER OF SUBJECTS IN EACH GROUP WHO COMMITTED ONE OR MORE SUCH ERRORS ON THE GOAL DIRECTED SERIAL ALTERNATION TEST

Group	First Half			Second Half			Total		
	$\bar{X}$	s	n	$\bar{X}$	s	n	$\bar{X}$	s	n
Controls	1.20	0.98	11	1.00	0.97	10	2.20	1.47	14
Short-term Alcoholids	1.13	1.02	10	0.87	1.37	6	2.00	2.13	11
Long-term Alcoholics	1.47	2.03	7	1.40	1.78	11	2.87	3.67	11

The groups were also compared on the frequency in which an alternation error was committed. In Table 20 is presented the frequency of instances and number of subjects who manifested such an error. Chi-square tests were calculated between the controls and the two alcoholic groups, but not between the latter two groups as no differences in the number of subjects who committed such an error obviously exist. The controls did not significantly differ from the short- (x^2 = 1.35, df 1, ns) and long-term alcoholics (x^2 = 3.47, df 1, ns) on the number of subjects within each group who committed one or more alternation errors. Nor was the comparison between the controls and the combined group of alcoholics significant (x^2 = 3.29, df 1, ns). Despite the fact that more alcoholics than controls tended to make alternation errors, the conclusion is never-

theless drawn that the groups are not distinguishable on this type of error.

TABLE 20

FREQUENCY OF TIMES AND NUMBER OF SUBJECTS IN EACH GROUP WHO COMMITTED AN ALTERNATION ERROR

Group	First Half		Second Half		Total	
	f	n	f	n	f	n
Controls	3	3	0	0	3	3
Short-term Alcoholics	5	5	4	4	9	7
Long-term Alcoholics	8	8	5	4	13	9

There are apparently no group differences on the number of instances or number of subjects within each group who lost their place during their performance of this task. In Table 21 are summarized the number of subjects and frequency of occurrence of this event. No inferential statistics were computed as it is evident that there are no differences between the three groups.

Five controls and five short-term alcoholics either forgot or disregarded the goal. Seven long-term alcoholics manifested a goal response error. Thus the groups are not differentiated in the capacity to retain "in mind" a goal response, and to terminate performance after its achievement.

Copying Test

The groups performed almost identically on the Copying Test. In Table 22 are presented the means and standard deviations for each

TABLE 21

FREQUENCY OF TIMES AND NUMBER OF SUBJECTS WITHIN EACH GROUP FOR WHOM A LOSS OF PLACE OCCURRED ON THE GOAL DIRECTED SERIAL ALTERNATION TEST

Group	First Half		Second Half		Total	
	f	n	f	n	f	n
Controls	2	2	1	1	3	3
Short-term Alcoholics	3	2	2	2	5	3
Long-term Alcoholics	4	1	3	2	7	2

TABLE 22

MEANS AND STANDARD DEVIATIONS FOR EACH GROUP ON THE COPYING TEST

Variable	Controls		Short-term Alcoholics		Long-term Alcoholics	
	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s
Part I						
Attempted	15.9	3.9	15.0	4.1	14.7	3.4
Correct	10.3	2.4	11.7	4.3	10.7	4.1
Part II						
Attempted	15.5	4.6	15.9	4.4	15.1	3.6
Correct	10.8	3.3	11.6	4.5	9.3	3.8
Total						
Attempted	31.7	7.7	30.9	8.3	29.8	6.5
Correct	21.1	5.1	23.3	8.5	20.1	7.0
Percent Correct	70.7	5.1	75.1	16.8	66.6	17.3

group on the number of items attempted and the number of items correct. The only measure on which the groups possibly differ is the percent of correct total answers. To formally test this, the data were submitted to an analysis of variance and it was found that the main effect for Groups was not significant ($F = 1.019$, df 2/42, ns). Hence it is concluded that an alcoholism history is not detrimental to performance on this test.

Correlations Between Tests

It was stated in the introduction that performance on these three tests might shed some light on the possible mechanisms accounting for the deficient performance of the alcoholics on the Wisconsin Card Sorting Test. In Table 23 are presented the correlations between the number of boxes completed on the Maze Tracing Speed Test, the trials and errors measures on the first seven sets and the number of set interruptions on the Wisconsin Card Sorting Test. It can be observed that none of the product moment correlations for the controls and long-term alcoholics were significant. In the short-term alcoholics, only the correlation with the number of spatial perseverations was significant. The significant negative correlation between spatial perseverations and performance on the Maze Test may be spurious, merely reflecting the fact that the more spatially adept the individual is, the less likely he is to manifest such spatial perseverations. What is more surprising is the finding that the controls and long-term alcoholics did not exhibit such a high correlation as well.

In Table 24 are summarized the correlations for the three groups between performance on the Copying and Wisconsin Card Sorting Tests.

TABLE 23

CORRELATIONS BETWEEN THE TOTAL NUMBER OF BOXES COMPLETED ON THE MAZE TRACING SPEED TEST AND THE TRIALS AND ERRORS MEASURES OF THE WISCONSIN CARD SORTING TEST

Variable	Controls	Short-term Alcoholics	Long-term Alcoholics
Trials	-0.22	-0.42	-0.25
Total Errors	-0.02	-0.47	-0.17
Perseverative Errors	+0.03	-0.43	-0.13
'Other' Errors	-0.04	-0.42	+0.34
Spatial Perseverations	-0.03	-0.62[a]	+0.22
Perseverative Errors within 10 Trials After a Set Shift	-0.31	-0.31	+0.21
Number of Interruptions	+0.19	-0.02	-0.44

[a] $p < .02$

TABLE 24

CORRELATIONS BETWEEN THE TOTAL PERCENT CORRECT ANSWERS ON THE COPYING TEST AND THE TRIALS AND ERRORS MEASURES OF THE WISCONSIN CARD SORTING TEST

Variable	Controls	Short-term Alcoholics	Long-term Alcoholics
Trials	-0.36	-0.35	+0.23
Total Errors	-0.34	-0.38	+0.13
Perseverative Errors	-0.31	-0.41	+0.03
'Other' Errors	-0.31	-0.39	+0.23
Spatial Perseverations	-0.16	-0.38	+0.11
Perseverative Errors within 10 Trials After a Set Shift	-0.26	-0.38	-0.14
Number of Interruptions	+0.11	+0.46	+0.26

Note that none of the correlations between these two tests are significant, suggesting that the flexibility of closure factor is not related to performance on the Wisconsin Card Sorting Test.

The correlations between the Goal Directed Serial Alternation Test and Wisconsin Card Sorting Test are presented in Table 25. For the controls and long-term alcoholics, none of the correlations reach statistical significance. In the short-term alcoholics performance on the two tests was correlated with respect to the number of perseverative and spatial errors. The significant positive correlations indicates that the longer the subject took to complete the Goal Directed Serial Alternation Test, the more perseverative and spatial errors he manifested on the Wisconsin Card Sorting Test.

The intercorrelations among the Maze, Copying and Goal Directed Serial Alternation Tests are summarized in Table 26. None of the correlations are significant in the controls and long-term alcoholics. It can be observed, however, that a significant negative correlation was obtained between the Maze and Goal Directed Serial Alternation Test in the short-term alcoholics, suggesting that the more boxes that were completed on the former test, the less time it took to complete the latter.

Thus with reference to the obtained intercorrelations, the controls and long-term alcoholics did not demonstrate an association between spatial, perceptual and attentional capacities and performance on the Wisconsin Card Sorting Test. Some of the intercorrelations in the short-term alcoholics were statistically significant, but the fact that they occurred in only this group forces the conclusion that the correlations attained significance by chance factors, or alternatively reflect

TABLE 25

CORRELATIONS BETWEEN THE TOTAL TIME SCORES ON THE GOAL DIRECTED SERIAL ALTERNATION TEST AND THE TRIALS AND ERRORS MEASURES OF THE WISCONSIN CARD SORTING TEST

Variable	Controls	Short-term Alcoholics	Long-term Alcoholics
Trials	-0.12	+0.51	+0.09
Total Errors	-0.03	+0.46	+0.06
Perseverative Errors	-0.24	+0.52[a]	+0.06
'Other' Errors	-0.10	-0.35	+0.10
Spatial Perseverations	0.00	+0.58[a]	0.00
Perseverative Errors within 10 Trials After a Set Shift	-0.35	+0.20	+0.03
Number of Interruptions	-0.28	-0.26	+0.03

[a] $p < .05$

TABLE 26

INTERCORRELATIONS BETWEEN THE GOAL DIRECTED SERIAL ALTERNATION TEST, COPYING TEST AND MAZE TRACING SPEED TEST FOR EACH GROUP

Test	Maze Tracing Speed Test	Copying Test	Goal Directed Serial Alternation Test	
Maze Tracing Speed Test		-0.07	+0.16	Controls
		+0.06	-0.57[a]	Short-term alcoholics
		+0.17	-0.23	Long-term alcoholics
Copying Test			-0.03	Controls
			-0.33	Short-term alcoholics
			-0.18	Long-term alcoholics

[a] $p < .05$

an idiosyncratic mode of functioning in that group. Of particular importance in this investigation was the finding that none of the correlations between the tests and the number of response set interruptions were significant, suggesting that the factors of perceptual closure, attention or spatial ability cannot account for this type of error.

Discussion

The results of this experiment must be interpreted with caution. First at the psychological level of analysis, it does not appear that the factors of spatial ability, attention or flexibility of closure are related to performance on the Wisconsin Card Sorting Test. The one possible exception to this conclusion was the finding that in the short-term alcoholics, several significant correlations were obtained among the perseverative and spatial errors indices of performance on the Wisconsin Card Sorting Test, the Goal Directed Serial Alternation Test and the Maze Tracing Speed Test. The precise meaning of these correlations in the short-term alcoholics is not clear, but it was hypothesized that they were either due to chance factors or reflected an idiosyncratic mode of functioning in that group.

The neuropsychological implications of this experiment are puzzling. The finding that alcoholism is detrimental to performance on the Maze Tracing Speed Test is in agreement with the previously reported impairment in patients with prefrontal lesions (Milner, 1964; Porteus, 1959). This result also confirms the observation by other authors of a defective spatial scanning capacity in chronic alcoholics as measured by another type of Maze test, the Trail Making Test (Fitzhugh *et al.*, 1965; Goldstein and Chotlos, 1965; Goldstein and Shelley, 1971).

The absence of an impairment however on the Copying and Goal Directed Serial Alternation Test stands in contrast to what would be expected if there existed a frontal lobe deficit in alcoholics. There are two alternative explanations to account for the intact functioning. First, it is possible that the tests are not sensitive enough to detect mild neurological impairment as would be expected from a chronic atrophying process. Whereas Luria (1966) noted an impairment in patients with acute cerebral lesions on a variant of the Goal Directed Alternation Test, it may be that the severity of the dysfunction in alcoholics is not great enough to elicit a decrement in performance. In other words, the test's threshold for identifying an impairment may be too high. The finding that the Copying Test was also unsuccessful at differentiating the groups may indicate that this instrument is not as sensitive as its correlate, the rod and frame test, in distinguishing field-independent from dependent individuals. The fact that this test correlates highly with the field independent-dependent mode of functioning (French et al., 1963), does not necessarily imply that it is as reliable in dichotomizing individuals along this dimension as work with the Embedded Figures Test has shown.

A second and equally viable alternative interpretation of the negative results is that alcoholics in reality do not suffer from a frontal lobe dysfunction. If this is the case, then a decrement in performance on these tasks would not be expected. The next section of this dissertation is devoted in large part to an extensive discussion of this alternative, namely, whether or not the hypothesis that chronic alcoholics are neurologically impaired in the frontal and frontal-limbic regions of the brain is tenable.

CHAPTER VI

GENERAL DISCUSSION

Before proceeding with an interpretation of the results reported herein, it is in order to first briefly review the findings of the three experiments. In Experiment I, both the short- and long-term alcoholics exhibited an impairment in maintaining a cognitive set on the Wisconsin Card Sorting Test. The long-term alcoholics also demonstrated an overall impairment as indexed by their trials and errors scores while the short-term alcoholics did not differ from the controls. In addition, the long-term alcoholics were deficient at error utilization and set shifting capacity. The three groups were not distinguishable in their "learning to learn" capacity or in their ability to identify simple concepts.

In Experiment II, where the criterion was three instead of ten consecutive correct choices, no differences were observed between the groups in set switching ability. It therefore appears that the manifestation of a set shifting deficit in the long-term alcoholics depends upon the prior establishment of a "strong" cognitive set. What constitutes a "strong" cognitive set cannot be precisely stated, suffice to say that ten consecutive positive reinforcements are sufficient while three are not. Presumably if one were to conduct a parametric investigation of this problem, a progressive impairment in shifting would be observed as the

criterion number of positive reinforcements is increased. The short- and long-term alcoholics committed more spatial perseverations than the controls; that is, emitted successive incorrect responses to the same stimulus card of the four alternatives. The long-term alcoholics responded or sorted at a faster rate than the other two groups and this was negatively correlated with the number of set interruptions.

The groups were not differentiated in the number of set interruptions, but since there was a trend in the expected direction, the failure to distinguish the groups was postulated to be due to the fact that only three sets were administered. A significant interaction between the groups was noted on the last three sets. While the controls exhibited an improvement, the alcoholic groups deteriorated in performance. This was hypothesized to be due to the differential effects that failure has on subsequent performance in each group. It was speculated that alcoholics are more susceptible than controls to the effects of failure on subsequent performance.

In Experiment III it was demonstrated that alcoholics are impaired in the capacities of spatial scanning and planning as illustrated by their performance on the Maze Tracing Speed Test. The finding that their performance on the Copying and Goal Directed Serial Alternation Tests was comparable to that of the controls indicated that the capacities of flexibility of closure and attention are not impaired. Except for some minor exceptions in the short-term alcoholics, the intercorrelations among these three tests and between the various measures of the Wisconsin Card Sorting Test were very low and not statistically significant.

The observation that the alcoholics were not impaired on all tests underscores the conclusion that alcoholics do not suffer from a global or generalized intellectual deterioration. Indeed, in addition to the above tests, the groups were not differentiated in their Shipley-Hartford scores or WAIS equivalent IQ, suggesting that there are dimensions of psychological functioning which are intact in alcoholics.

The results of the three experiments are interpreted as implicating a neurobehavioral dysfunction in the chronic alcoholic. Because deficits were not found on all tasks and measures, in addition to the fact that general intellectual capacity was intact, it was speculated that the neurological focus would most probably also be circumscribed. On the basis of behavioral data, it has been theorized (Jones and Parsons, 1971; Tarter and Parsons, 1971) that alcoholics are impaired in the prefrontal and/or subcortical regions of the brain. Before discussing the results of the present investigation with respect to the above hypothesis, it is best to outline first the neuroanatomical and neurophysiological relationships between the prefrontal and subcortical regions of the brain.

Neuroanatomical Relations

Fulton (1952) and Pribram (1958) have postulated that the prefrontal cortex and subcortical structures are functionally interrelated. Lesions to subcortical structures often produce the same behavioral deficits that are found after lesions to the prefrontal cortex. Pribram (1958) has further speculated that the prefrontal region functions as the association area for the limbic system. Nauta (1964) has provided some confirmatory evidence. On the basis tissue degeneration techniques,

he has been able to map a topographical organization of fiber tracts that emanate from the prefrontal cortex. Fibers from the dorsolateral area project to the superior temporal gyrus while those from the basal orbital area project to the middle and inferior temporal gyri; both tracts projecting to the temporal lobe via the fasciculus uncinatus.

A frontal-hypothalamic tract has also been discovered (Le Gros Clark, 1948; Marsala and Grofova, 1962). In fact it has been hypothesized by Le Gros Clark (1948) that the hypothalamus functions as a primary projection area just as does the striate cortex for the visual system. Nauta (1962) supports this thesis with the statement:

> It will suffice here to point out that the hypothalamic neurons in question combine characteristics of nerve cells and secretory cells and are thought to elaborate humoral principles, some of which are hormones, or their precursors, in their own right, whereas others serve as transmitter substances affecting the secretory mechanisms of the anterior pituitary. Whatever their glandular characteristics, these cells must nevertheless, be regarded as the last neuronal link in the major endocrine motor organization and hence, as an unusual sort of 'final common path.' Experimental as well as clinical data suggest that, obviously the whole of the neocortex is engaged in the overall function of differential anticipatory behavior, rostral parts of the frontal, and to some extent also the temporal lobes are of special significance for the 'anticipation and planning as it applies to both the self and the species.' It is therefore of great interest that the only known neocortical projections to the 'limbic system-midbrain circuit,' in which the hypothalamus lies embedded, arise from precisely these cortical areas.

A hypothalamic-frontal tract has been identified (Le Gross Clark and Meyer, 1950); synapsing first in the dorsomedial nucleus of the thalamus before projecting to the prefrontal areas. Three important tracts emanating from the dorsomedial nucleus of the thalamus project to the prefrontal regions; the pars paramellaris to the frontal eyefields, the pars parvocellularis to the dorsolateral region, and the pars magnocellularis to the orbital region.

The prefrontal cortex has in addition been demonstrated to have reciprocal anatomical connections with the extrapyramidal system. However, because a discussion of this system would not contribute to the present analysis, it shall not be reviewed here. The interested reader is referred to Brutkowski (1965), Warren and Akert (1964) and Riklan and Levita (1969) for comprehensive summaries of the neuroanatomical interrelationships between the frontal lobes and these subcortical structures.

The results of the present experiments confirm (although not conclusively) the hypothesis that alcoholics exhibit behaviors similar to that manifested by patients (and primates) with prefrontal, limbic and hypothalamic lesions. Taking the observed deficits one at a time, the case for an anterior-basal focus of neurological impairment will be presented.

Results Congruent with an Anterior-Basal Focus

Maintenance of a Cognitive Set

One of the most striking results of this investigation was that the alcoholics were impaired at sustaining a cognitive set over a series of positively reinforced trials. This finding concurs with the clinical observations by Wechsler (1941) that alcoholics are impaired at task persistence. Similarly Parsons and Holloway (1970) have demonstrated that alcoholics were unable to maintain a set in a two-choice reversal shift procedure. In a different context, Chambers and Wilson (1968) observed that alcoholics were deficient at remembering the order in which a sequence of nine lights were lit.

Stamm (1964) has concluded from an extensive investigation of

discrimination learning deficits in prefrontal monkeys that

> these results point to the importance of the frontal lobes during the phase of learning that occurs after the monkey has made one or more correct responses and when further improvement on the task requires the consolidation and integration of correct response patterns. This performance requires the monkey's efficient utilization of prior experience on the task for integration of correct response patterns.

Pribram (1969) in a theoretical paper hypothesized that the frontal lobes serve to temporally organize behavior by suppressing interfering inputs. Damage to this region of the brain it was theorized would result in an incapacity of the animal to mediate behavior along a temporal continuum. Support for Pribram's (1969) position was provided by Tubbs (1969) who found that monkeys with prefrontal lesions were deficient on a delayed alternation task. When the temporal parameters were manipulated by parsing or chunking each pair of left-right alternations into a discrete unit, no impairment was manifested by the animals.

Korsakoff patients have also been demonstrated to be impaired at integrating behavior along a temporal continuum (Talland, 1965). Williams and Zangwill (1950) reported that Korsakoff patients suffered from an agnosia of succession, while Lidz (1942) observed that the Korsakoff patient was unable to comprehend sequences. It is interesting to note that alcoholics exhibit a similar deficit to that seen in Korsakoff patients, the latter type of patients having documented structural lesions in the limbic system (Meissner, 1967; Talland, 1965). Thus an impairment in behavioral sequencing has been found in alcoholics, frontally lesioned primates and Korsakoff patients, implicating a frontal-limbic focus for this type of pathological disruption.

The mechanisms of the deficit are however not known. It is

possible since this test does involve an interval between card selection and response that it is an accompanying impairment associated with deficits on tasks that involve delayed responding. Such impairments have been reported in frontally lesioned animals (Warren and Akert, 1964) and humans (Milner, 1964). Another alternative is that it may reflect an impairment in short-term memory similar to that which has been found in Korsakoff patients (Talland, 1965). Or finally, the deficit may in itself reflect a unique pathological disturbance, and not be a by-product of a more basic dysfunction. Further research is needed to carefully evaluate these alternatives.

Error Utilization

A second deficit noted in this investigation was that the long-term alcoholics were impaired at error utilization. That is to say, if an incorrect response was emitted, the subsequent response was more likely to also be incorrect in the long-term alcoholics than the other two groups. This finding is in keeping with the human and animal studies. Miles (1964) reported that monkeys with prefrontal lesions had a greater propensity to have one incorrect response follow another. Konow and Pribram (1970) have observed an impairment of error utilization in a patient with an anterior frontal tumor. The patient was able to recognize an error that she committed during performance, but was unable to utilize the information from the error. Thus the alcoholic resembles the prefrontal subject with respect to an inability to utilize errors so as to make the appropriate behavioral adjustment and shift strategy in pursuit of the solution to the problem.

Spatial Perseverations

A third deficit observed in the alcoholics was that they manifested more spatial perseverations than the controls. In other words, if an incorrect response was emitted, the alcoholics exhibited a greater tendency than controls to succeed that response with a subsequent incorrect response to the same place of the four possible alternatives. Perseveration of a spatial nature, that is, the repeating of a place response has often been observed in frontally lesioned animals, and may in fact be the most commonly observed behavioral deficit consequential to ablation of this region of the brain (Mishkin, 1964).

Set Shifting Ability

Another impairment noted was that the long-term alcoholics manifested a greater propensity to perseverate after a new set was introduced, but this was contingent upon the prior establishment of a "strong" cognitive set. Thus some evidence was accrued which indicates that the long-term alcoholics are impaired in their capacity to shift sets. Perseveration of a set has been reported in frontally lesioned animals (Mishkin, 1964) and humans (Milner, 1963; 1964). Indeed, Mishkin (1964) and Battig, Rosvold and Mishkin (1962) have theorized on the basis of lesion studies that one of the most important functions of the prefrontal cortex is to inhibit competing response tendencies. Brush, Rosvold and Mishkin (1961) conducted a very provocative experiment in which it was demonstrated that frontally ablated animals were impaired only when it involved the changing of an initial or acquired preference. The results of the present investigation are in partial agreement with those of Brush *et al.* (1961). The alcoholics exhibited a greater inclination to

perseverate when a "strong" cognitive set (ten consecutive reinforcements) had been established, but were not different from controls when a "weak" set (three consecutive reinforcements) was established. Thus the emergence of a deficit in set shifting was contingent upon first establishing a "strong" set; or acquired preference to respond in a particular fashion. It remains for further research to determine if alcoholics are more reluctant than nonalcoholics to shift away from an initial preference, a characteristic impairment of frontally lesioned animals (Brush et al., 1961).

Spatial Scanning

And finally, alcoholics were found to be impaired at spatial scanning and planning, two characteristics which have been reported to be consequential to a prefrontal lesion. Humans with prefrontal damage are impaired at searching a complex visual field (Teuber, 1964). Porteus (1959) and Milner (1964) have observed that damage to the prefrontal areas drastically reduces the subject's ability to traverse a stylus maze. The impaired performance of the alcoholics in this investigation on the Maze Tracing Speed Test reflects an analogous deficit. The Maze Tracing Speed Test reputedly also measures planning capacity (French et al., 1963). A deficit in foresight has been reported by Milner (1964) on the stylus maze; and Pribram (1960) has theorized that the frontal lobes are instrumental for intact planning. The results obtained herein reflect an impairment in planning and spatial scanning, thereby implicating the frontal region of the brain as the source of the pathology.

Results Inconsistent with an Anterior-Basal Focus

"Learning to Learn"

Other results do not support the hypothesis that alcoholics suffer from a prefrontal-subcortical impairment. The fact that the three groups were not different in their rate of inter-set improvement or "learning to learn" might be considered to be contrary to what would be expected if a prefrontal focus of pathology was extant. However, a review of the relevant literature leads one to conclude that even in primates surgically lesioned in the prefrontal area, a "learning to learn" deficit is not inevitable. For example, Oxbury and Weiskrantz (1962) and Miles (1964) observed no impairment in interproblem learning in monkeys after frontal ablations. Warren (1964) in a review of the literature concluded that the manifestation of a "learning to learn" deficit was contingent upon several factors, the most important of which was familiarity with the discriminanda. The more familiar the animals were with the discriminanda, the more severe was the "learning to learn" deficit. Warren (1964) postulated that the familiarity was essential so that perseverative interference can then be built up, a hypothesis somewhat analogous to that of Brush *et al.* (1961). It is doubtful that in the Wisconsin Card Sorting Test, the subject ever acquires familiarity with the sixty cards (discriminanda). But because the procedures between the Wisconsin Card Sorting Test and the two-choice discrimination paradigm are so vastly different from each other, it is difficult to evaluate the effects that familiarity may have had on performance. Suffice to say that even in the prefrontally ablated animal, a "learning to learn" deficit is not necessarily manifested.

Attention and Flexibility of Closure

Failure to observe differences between the controls and alcoholics on the Goal Directed Serial Alternation Test weighs heavily against positing a frontal lobe impairment. Luria (1966) has reported from case studies that an impairment on this type of test is a cardinal feature of a frontal lobe deficit. Another measure on which the alcoholics performed competently was the Copying Test, indicating that flexibility of closure or its correlate, field-dependency was not markedly different from that of the controls. It deserves to be mentioned in this context that alcoholics have also not been typically found to be more field-dependent than controls on the Embedded Figures Test (Burdick, 1969; Goldstein et al., 1970; Jones and Parsons, 1970; and Rhodes et al., 1968). It is possible therefore that the Copying and Embedded Figures Tests are not as capable at identifying field-dependency as the rod and frame test. The intactness of attentional and closure capacities tends to argue against a frontal lobe impairment, although the question can be raised that these instruments are not sensitive enough to detect a deficit from an atrophying process as compared to the more severe disruption caused by a lesion or tumor.

Intact Processes

The other facets of psychological functioning that were found to be unimpaired in the alcoholics have also been reported to be intact in frontally lesioned humans. The alcoholics in the present investigation were able to identify simple concepts as indicated by their performance on the first set of the Wisconsin Card Sorting Test. Similarly, Milner (1963) has observed that prefrontally ablated patients performed

as well as controls on the first set. General intellectual ability, at least as measured by the Shipley-Hartford Institute of Living Scale, was also intact in the alcoholics. Hebb and Penfield (1940) have similarly reported that the bilateral removal of the frontal lobes did not result in any appreciable change in psychometric intelligence.

Corroborative Evidence for an Anterior-Basal Focus

Motor Impulsivity

Results from other investigators have provided corroborative evidence in support of the postulate that alcoholics suffer from a neurological impairment to the frontal lobes. Edelberg (1970) has found that alcoholics were less able than controls to sustain a slow motor act. In that experiment the subjects were required to rotate a knob through a 180° arc as slowly as they possibly could. He found that the alcoholics turned the knob at a faster rate than the controls and interpreted this finding as reflecting a defect of motor inhibition in alcoholics. This conclusion is in agreement with the theory advanced by Stanley and Jaynes (1949) that the frontal lobes function in "act inhibition." Zangwill (1966) has proposed the German term Antrieb - "the ability to maintain an action, regardless of the time the patient needs" to describe what is disrupted after a frontal lobe lesion. The defect in sustaining a slow motor act described by Edelberg (1970) can be interpreted as reflecting a similar impairment as that observed in frontally lesioned humans and primates. By the same token, the more rapid rate of responding by the long-term alcoholics in this investigation may be due to a similar process of impulsivity or disinhibition. Paradoxically on the Wisconsin

Card Sorting Test it has adaptive significance in that for the long-term alcoholics the rate of responding is significantly and negatively correlated with the number of set interruptions.

Neuropsychological Tests

The performance decrement exhibited by chronic alcoholics on the Halstead-Reitan Battery also suggests a frontal neuropathological focus. Halstead (1964) has claimed that patients with a frontal lesion typically perform poorly on the Categories and Tactual Performance Tests. Accordingly, he maintains that seventy-five percent of frontally damaged patients can be identified by these two measures. Fitzhugh et al. (1960, 1965) have found that alcoholics do in fact perform significantly more poorly than controls on these two tests. Goldstein and Shelly (1971) also reported an impairment on the Categories and Tactual Performance Tests. Fitzhugh et al. (1960, 1965) and Goldstein and Chotlos (1965) have likewise found that alcoholics were impaired on the Trail Making Test, indicating an incapacity in spatial scanning. Thus evidence can be gleaned from standardized neuropsychological tests to implicate a frontal deficit.

Field Orientation

The field-dependency that has often been observed in alcoholics on the rod and frame test (Bailey et al., 1961; Goldstein and Chotlos, 1965; Jacobson, 1968; Jacobson et al., 1970; Karp et al., 1963, 1965a, 1965b; Karp and Konstadt, 1965, and Witkin et al., 1962) can be interpreted as reflecting a frontal lobe dysfunction. The demonstration that performance on the rod and frame test is not correlated with dependency measures of personality (Goldstein, Neuringer, Reiff, and Shelly, 1969)

suggests that there may be an organic basis for this mode of perceptual orientation. Indeed, Teuber (1964) has reported that damage to the prefrontal region of the brain, particularly the frontal eyefields, invariably results in a field-dependent mode of perceptual orientation. Although personality variables may be operative in the situation (Karp et al., 1965a, 1965b, Karp and Konstadt, 1965), it is at least equally possible that the field-dependency in alcoholics is a result of a brain dysfunction to the frontal areas.

There is thus substantial behavioral evidence to buttress the anatomical (Alexander, 1941; Courville, 1955, Creutzfeldt, 1928) and neurological (Lereboullet and Pluvinage, 1955; Lereboullet et al., 1955, Segal, Kushnarev, Urakov, and Misionzhnik, 1970 and Tumarkin et al., 1955) findings of an organic impairment to the frontal lobes. Of the eight measures which tap frontal lobe functions, five indicated a clear impairment while only two were disconfirming. Another index ("learning to learn") did not differentiate the groups, but as was discussed, a frontal lobe lesion does not necessarily result in a behavioral impairment in interproblem learning. Thus by means unequivocal, there is enough evidence to lend credibility to the notion that alcoholics suffer from a frontal-subcortical focus of dysfunction.

Subcortical Focus of Impairment

Because of the intimate relationship between the frontal, limbic and diencephalic structures, it would be expected that damage to one part of the system would be reflected by a dysfunction in another part of the system. In other words, though a specific region may be implicated, it is in fact several neuronal systems of which the referent region is part

that are disrupted. The ensuing discussion will concentrate on the evidence pointing to a limbic and diencephalic disturbance in alcoholics. However, it should be recognized by the reader that these latter regions of the brain do not function independently. As previously stated the frontal, limbic and diencephalic regions function conjointly.

Pathological alterations in brain tissue bordering the ventricles have been known for quite some time. Bender and Schilder (1933) concluded from an exhaustive neuropathological investigation that

> the lesions always occur in parts of the central nervous system which are adjacent to the spinal fluid and are most severe where the spinal fluid flows least freely, especially in the ventricular system. There is a tendency toward a specific electivity for gray masses and especially for vegetative gray masses along the ventricles.

Haug (1969) has recently confirmed this result with the pneumoencephalographic finding that the third ventricle in alcoholics is abnormally enlarged, presumably producing a pathological change in the adjacent gray matter. Segal et al. (1970) have also concluded that the area around the third ventricle is disrupted. Because of the location of the third ventricle, any enlargement or expansion would necessarily affect the medial nuclei of the thalamus. As has been previously discussed, the dorsomedial nucleus of the thalamus projects three important tracts to the orbital, lateral and eyefield areas of the frontal lobes. Another tract, emanating from the hypothalamus synapses in the dorsomedial nucleus of the thalamus before continuing on up to the frontal lobes. It is therefore conceivable that the enlargement of the third ventricle by disrupting the activity or destroying the dorsomedial nucleus would produce a diencephalic-frontal disconnection. Indeed such an hypothesis had already been advanced by Creutzfeldt (1928).

Behavioral and physiological data support the above findings of a diencephalic disorder in chronic alcoholics. Segal et al. (1970) on the basis of the extensive study of alcoholics during alcohol withdrawal concluded that the disturbances found in the homeostatic regulating systems and affective behavior were a consequence of the interaction of alcohol with the hypothalamus and hypophysis (pituitary gland). According to Segal et al. (1970) the "affective pathology is associated with the prefrontal cortex-hypothalamus-hippocampus-temporal parietal system." Though this encompasses a sizeable portion of brain mass (the frontal region alone comprises 29% of the brain mass in man, Brodmann, 1909), it emphasizes the magnitude of the neuropathological alterations and as well as the intricacy and complexity of the neuronal systems in the anterior-basal area of the central nervous system.

Added credibility to a diencephalic disturbance is obtained if the acute effects of alcohol are also considered. Masserman (1958) demonstrated that alcohol activates the hypothalamus and corticotrophic functions of the hypophysis. Wayner (1970) reported that a dose of alcohol as small as 0.01 g/kg increased the spontaneous firing rate of sodium sensitive lateral hypothalamic neurons. It is therefore entirely possible that the chronic ingestion of ethanol could effect a permanent functional and/or structural change in the region of the hypothalamus. Added impetus to this notion is given by the fact that the hypothalamus, particularly the lateral aspect, is among the most highly vascularized regions of the brain (Finley, 1940), suggesting that the toxic substance, either alcohol or a by-product, may be transported via the vascular system and thus effect a pathological change in this area. By the same

token it has been postulated by Bender and Schilder (1933) that the toxic agent is transported in the cerebrospinal fluid to the ventricles. Further research is needed to elucidate which of these two transport systems is more active in carrying the noxious agent.

In conclusion, it appears that there is a substantial amount of evidence at the anatomical, neurological and behavioral levels of analysis to suggest that chronic alcoholics suffer from a neuropathological impairment to the frontal and basal regions of the brain. Though it is not possible to precisely specify a more focalized locus of impairment, it is important to remember that the frontal and subcortical systems are functionally interrelated (Nauta, 1964; Pribram, 1960). Thus further localization of the deficit may not even be possible, especially if one adopts the view that chronic alcohol ingestion is deleterious to specific neurophysiological systems, rather than to isolated geographic regions of the brain.

Personality Factors

The preceding discussion argued for a neurological explanation of the results. However, other factors may have contributed to the obtained results, namely personality, motivational and nutritional variables. To examine personality and psychopathology, the MMPI's of the long- and short-term alcoholics were analyzed. Unfortunately no profiles were available for the controls, but it was decided to proceed with the analysis anyway since it was speculated that it might shed some light on the possible factors that differentiated the short- and long-term alcoholics on the measures of error utilization, rate of responding and the trials and errors indices of the Wisconsin Card Sorting Test. Of the

sixty alcoholics who participated in this investigation, MMPI's were obtained for fifty of them, twenty-four short-term and twenty-six long-term. In Table 27 the means and standard deviations on the raw scores for each group are presented. Note that on the validity and nine clinical scales the two groups perform almost identically. It can also be seen that the two groups do not differ on the two factored scales of repression and anxiety. In addition, ego-strength did not differentiate the groups. Both groups performed alike on the acquiescence scale (Shaffer, 1963), a measure of the degree to which the individual's passivity determines his mode of responding on this test. On the basis of these results it is concluded that personality and psychopathological variables cannot be invoked to explain the performance differences between the short- and long-term alcoholics.

Motivational Variables

Motivational factors do not appear to be able to explain the obtained results. Since the nature and objectives of the investigation were explained to each subject before testing, and the fact that participation was voluntary suggests that the subjects cooperated for either altruistic reasons or to pass the time of day. In addition, if the alcoholics were not motivated to perform, one would expect to see a performance decrement on all of the tests. However because impairments were found on some measures and not on others, it must be concluded that the behavioral deficits were not a function of disinterest and lack of motivation. And finally, at least within the alcoholic groups, it can be seen in Table 27 that the two groups did not differ in passivity or acquiescence. The evidence therefore argues in favor of rejecting the no-

TABLE 27

PERFORMANCE OF SHORT- AND LONG-TERM ALCOHOLICS ON THE CLINICAL AND SELECTED PERSONALITY SCALES OF THE MMPI[a]

Scale	Group			
	Short-term Alcoholics		Long-term Alcoholics	
	$\bar{X}$	s	$\bar{X}$	s
Validity Scales				
F	8.9	5.2	8.5	6.1
K	11.5	4.7	10.8	4.5
Clinical Scales				
Hypochondriasis	17.7	5.4	18.6	7.7
Depression	26.4	6.3	27.6	5.7
Hysteria	24.8	6.0	26.2	7.5
Psychopathic-deviate	27.8	3.9	29.5	5.4
Masculinity-femininity	25.2	5.2	24.6	4.3
Paranoid	12.2	4.4	12.3	4.3
Psychasthenia	31.0	5.8	31.7	8.2
Schizophrenia	29.4	9.4	30.4	12.5
Mania	22.7	6.9	22.1	5.9
Personality Scales				
Repression	15.0	5.6	15.4	4.4
Welsch's Anxiety	19.1	8.8	21.5	9.9
Ego Strength	39.3	6.8	36.4	8.4
Acquiescence	24.0	5.3	24.9	4.8

[a]Raw scores

tion that motivational variables such as interest, ego involvement, and effort can account for the obtained results.

Nutritional Status

Nutritional deficiencies, particularly hypovitaminosis has often been reported in Korsakoff patients (Talland, 1965). Specifically a depletion of thiamine is found in these patients. It is therefore of importance to evaluate the nutritional status of alcoholics since it may be possible that the behavioral impairments observed are not the result of the toxic effects of alcohol on the nervous system, but rather due indirectly to a vitamin deficiency which reduces the individual's cerebral competency. Because no direct tests of nutritional status were conducted in this investigation, any conclusions drawn must be based on inference alone. Two reasons tend to negate the factor of nutrition as explaining the results. First, all of the alcoholic patients after admission to the hospital were administered daily vitamin supplements in addition to receiving a balanced diet. Since psychological testing was not initiated for at least one month after admission, it is possible that any vitamin deficiency that existed may have been resolved or at least minimized at the time of testing. Secondly, it has been reported that alcoholics when equated for socioeconomic class, do not differ from nonalcoholics in nutritional status. Neville, Eagles, Samson and Olson (1968) concluded that their "results do not support the view that the nutritional status of alcoholics is markedly inferior to that of nonalcoholics, particularly those of similar economic and health histories." Though no information was systematically gathered pertaining to the social status of the subjects, it is highly unlikely that the controls

were different from the alcoholics on this dimension. If anything, the alcoholics as a group are of a higher socioeconomic status than the controls. This is attributable to the fact that the alcoholism treatment program at the Oklahoma City V.A. Hospital is unique in the State of Oklahoma, and thus attracts a wide spectrum of individuals ranging from the blue-collar worker to professional and executive. The controls on the other hand tend to be a more homogeneous group, being largely comprised of lower to lower-middle class individuals. Although a definite conclusion cannot be drawn, the available evidence indicates that the alcoholics who participated in this investigation did not suffer from a debilitating nutritional deficiency. However, further research is needed to evaluate the influence of nutritional factors on psychological test performance.

In summary, it is concluded that alcoholics suffer from a neurobehavioral impairment associated with neuropathological changes in the anterior-basal region of the brain. Evidence gleaned from anatomical, neurological and behavioral research strongly implicate a frontal-limbic-diencephalic disturbance. Several important problems however still remain to be investigated. First, the precise role of nutritional factors needs to be elucidated. Secondly, it would be invaluable to an understanding of the brain mechanisms involved if neurological and behavioral data could be conjointly collected and then correlated. Another avenue of research would entail further systematic investigation of the neuropsychological impairments. Although the hypothesis of a frontal-subcortical dysfunction was largely supported in this investigation, further research testing a greater spectrum of functions - cognitive, affective

and psychophysiological is necessary for verification. It would also be useful to determine if a partial or complete recovery of functions can be achieved after an extended interval of abstinence. And finally, a great deal remains to be determined regarding the toxic effects of alcohol on the brain, particularly the amount and duration period of ethanol ingestion that is required before a neuropathological alteration of brain tissue takes place. Utilizing nonhuman primates as subjects, it can be determined where the neuropathological focus first appears, its expansion in the brain and the point at which the impairment becomes irreversible. All of this can be done in conjunction with behavioral testing.

The history of alcohol use and abuse dates back many centuries. But it is only in this century that chronic alcoholism came to be accepted as a medico-psychological and not a moral problem. Ranking third in the United States with respect to the number of people afflicted, it is unquestionably a national problem of epidemiological proportions. Hopefully the results of the investigation reported herein have contributed to an understanding of the disease process. Much however still remains to be learned.

CHAPTER VII

SUMMARY

Three experiments were conducted with the aim of elucidating the cognitive impairment in chronic alcoholics. The Wisconsin Card Sorting Test was administered in Experiments I and II to three groups of subjects; short-term alcoholics (an admitted alcoholism history of less than ten years), long-term alcoholics (an admitted alcoholism history in excess of ten years) and normal controls. Fifteen subjects comprised each group. In the third experiment, the same subjects who participated in Experiment II were utilized. They were administered three tests; the Maze Tracing Speed Test, Copying Test and Goal Directed Serial Alternation Test. These instruments measure the capacities of spatial scanning and planning, flexibility of closure and attention. It was hoped that these three tests might provide information regarding the source of the deficit on the Wisconsin Card Sorting Test as well as aid in the identification of a possible neuropathological focus.

In Experiment I, it was observed that the long-term alcoholics performed significantly more poorly than the controls and short-term alcoholics on the trials and errors measures of the Wisconsin Card Sorting Test while the latter two groups did not differ from each other. In addition, the results indicated that the long-term alcoholics were impaired

in error utilization and shifting sets. Both the short- and long-term alcoholics exhibited a marked deficit in set persistence when compared to the controls.

In Experiment II three consecutive positive reinforcements were given before a set switch and it was found that no impairment in shifting sets was manifested in the alcoholics. Thus in the first experiment where ten consecutive positive reinforcements were administered, it was observed that the long-term alcoholics had difficulty in shifting sets, while in the second experiment where only three positive reinforcements were administered, no deficit was noted. The alcoholic groups did however exhibit a significantly greater proportion of spatial perseverations; that is, emitted two or more consecutive incorrect responses to the same position of the four alternatives. It was also noted that the long-term alcoholics sorted or responded at a faster rate than the other two groups, and this was found to be negatively correlated with the number of response sequence interruptions. The more rapid they responded, the less interruptions that were committed. When the level of difficulty was lowered on the last three sets, by employing ten consecutive positive reinforcements as the criterion, it was observed that the controls evidenced an improvement while the alcoholic groups' performance continued to deteriorate. This suggests that the prior seven sets (being much more difficult) represented a condition of failure to the alcoholics, and thus when the task requirements were made more easy, the effects of this failure carried over to the subsequent three sets. The controls, on the other hand, were not so affected by the failure and were thus able to initiate an improvement in performance.

In Experiment III, the Maze Tracing Speed Test was performed more poorly by the alcoholics than the controls, but the Copying and Goal Directed Serial Alternation Tests did not discriminate between the groups. Correlations among these three tests were nonsignificant as were the correlations between these tests and the Wisconsin Card Sorting Test measures in the controls and long-term alcoholics. Several of the intercorrelations in the short-term alcoholics attained significance, but the fact that they occurred in only this group was hypothesized to reflect chance factors or an idiosyncratic mode of functioning in this group.

Personality and motivational variables cannot account for the results. Nor can a generalized intellectual impairment be invoked to explain the findings since the alcoholics did not differ from the controls in intellectual ability as measured by the Shipley-Hartford Institute of Living Scale. It is possible that nutritional factors may have contributed to some extent, although the probability of such is not likely. Further research in which nutritional status is controlled is necessary however before it can be conclusively ruled out as a contributing variable. Several avenues of research were proposed, which it is hoped will shed further light on the nature and extent of the neurological and behavioral deficits that are consequential to a longstanding history of chronic alcohol abuse.

In summary, the neurobehavioral deficits exhibited by chronic alcoholics in this and other investigations support the anatomical and neurological evidence for a frontal-limbic-diencephalic focus of neuropathological involvement. The deficits manifested by chronic alcoholics are similar in type to those found in humans and animals with lesions in

these areas of the brain. Ideally however, it would be desirable to corroborate these findings in a group of subjects with verified structural lesions.

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APPENDIX

PLEASE NOTE:

Pages 138-143, "Maze Tracing Speed Test", ©1962 by Educational Testing Service not microfilmed at request of author. Available for consultation at University of Oklahoma Library.

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