379
N81d
No. 398c

PERFORMANCE OF BRAIN-INJURED VERSUS NON-BRAIN-INJURED
INDIVIDUALS ON THREE VERSIONS OF THE CATEGORY TEST

DISSERTATION

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Walt N. Mercer, B.S., M.R.E.

Denton, Texas

August, 1994

379
N81d
No. 398c

PERFORMANCE OF BRAIN-INJURED VERSUS NON-BRAIN-INJURED
INDIVIDUALS ON THREE VERSIONS OF THE CATEGORY TEST

DISSERTATION

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Walt N. Mercer, B.S., M.R.E.

Denton, Texas

August, 1994

CH

Mercer, Walt N., Performance of brain-injured versus non-brain-injured individuals on three versions of the Category Test. Doctor of Philosophy (Counseling Psychology), August 1994, 135 pp., 16 tables, 1 illustration, references, 169 titles.

To date, no research exists examining criterion-related validity of alternate, computerized forms of the Category Test. The intent of this study was to address criterion-related validity of three full forms of the Category Test. In that, the goal was to examine equivalency of each version in their ability to differentiate brain-injured from non-brain-injured individuals.

Forty-nine ($N = 49$) healthy adults and 45 ($N = 45$) brain-injured adults were tested using three versions of the Category Test, the BDI, and the WAIS-R NI. ANOVA indicated no significant differences between versions of the Category Test or an interaction between Category Test version and group membership on the total error score. MANOVA performed between versions of the Category Test and Subtest error scores indicated significant differences between versions on Subtest 3 and Subtest 6. Group membership (brain-injured v. non-brain-injured) produced a significant main effect on all subtests of the Category Test except Subtest 2. Several exploratory analyses were performed examining the

relationship between neuropsychological impairment, group membership based on Category Test error scores, and the WAIS-R NI. Clinical applications, such as the use of serial testing to index neurorehabilitation gains, were discussed.

ACKNOWLEDGEMENTS

I would like to express my appreciation to my co-chairs and mentors, E. H. Harrell, Ph.D. and Daniel Miller, Ph.D. Regardless of the demands on their time, they have always been available and provided considerable guidance throughout this project. I would like to express my indebtedness to George Bolden and Bruce Jones, Ph.D. for their help in securing brain-injured participants and Daniel Rockers and Christine Hudson for their help in data collection. I wish to thank Neal W. Mercer and Judith W. Childs who have provided continued backing throughout our graduate careers. I would like to thank Helen W. Childs who not only participated in this project but has continually provided support and guidance throughout all my pursuits.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS.....	iii
LIST OF TABLES.....	v
ILLUSTRATION.....	vii
CHAPTER	
I. INTRODUCTION.....	1
History of the Category Test	
Hypothesized Neuropsychological Abilities	
Measured by the Category Test	
Localization of Function by the Category Test	
Psychometric Properties of the Category Test	
Short Forms of the Category Test	
The Category Test with Specific Populations	
Automation and the Category Test	
Purpose	
II. METHOD.....	44
Subjects	
Instrumentation	
Procedure	
III. RESULTS.....	52
IV. DISCUSSION.....	61
APPENDICES.....	75
REFERENCES.....	112

LIST OF TABLES

Table

B-1.	Summary of Control Group Demographic Information.....	79
B-2.	Summary of Brain-Injured Group Demographic Information.....	80
B-3.	Summary of Control Group Descriptive Test Results.....	83
B-4.	Summary of Brain-Injured Group Descriptive Test Results.....	87
B-5.	Summary of MANOVA Results on the Category Test.....	91
B-6.	Summary of Subtest Means on Three Versions of the Category Test.....	94
B-7.	Summary of Univariate F-Tests for the WAIS-R NI for the Main Effect of Group Membership (Brain-Injured v. Non-Brain-Injured).....	95
B-8.	Summary of Point-Biserial Correlations Between Neuropsychological Impairment and WAIS-R Intelligence Quotients and Factor Scores.....	97
B-9.	Summary of Descriptive Test Results for Group Membership Based on Category Test Total Error Score.....	98
B-10.	Summary of Univariate F-Tests for Group Membership Based on Category Test Total Error Score.....	100
B-11.	Summary of Point-Biserial Correlations for Group Membership Based on Category Test Total Score.....	101

B-12.	Summary of Pearson Product-Moment Correlation Coefficients for Control Group, Brain-Injured, and Total Sample on Measures that Assess Abstraction, Visuospatial Skills, Attention/Concentration, Short-Term Memory, and Psychomotor Speed.....	102
B-13.	Summary of Pearson Product-Moment Correlation Coefficients for Control Group, Brain-Injured, and Total Sample on WAIS-R and WAIS-R NI Measures that Assess Short-Term Memory.....	104
B-14.	Summary of Descriptive Test Results for Group Membership Based on Category Test Subtest 7 Error Score.....	106
B-15.	Summary of Univariate F-Tests for Group Membership Based on Category Test Subtest 7 Error Score.....	108
B-16.	Summary of Point-Biserial Correlations for Group Membership Based on Category Test Subtest 7 Error Score.....	109

ILLUSTRATION

C-1.	Representation of Mean Performance on Three Versions of the Category Test	
	Total Score.....	111

CHAPTER I

INTRODUCTION

In the area of brain-injury research, a comparison of three, full forms of the Category Test has not been completed. The possibility exists, with computerization, that at least three parallel forms of the Category Test are available for use in neuropsychological assessment. If these three forms represent parallel forms of the Category Test, then equivalency should exist in their ability to differentiate brain-injured from non-brain-injured individuals. However, to date, no research exists examining criterion-related validity of alternate, computerized forms of the Category Test. The intent of this study was to address criterion-related validity of three full forms of the Category Test. In that, the goal was to examine equivalency of each version in their ability to discriminate brain-injured from non-brain-injured individuals.

For purposes of introduction, the writer examines the following: (a) history of the Category Test, (b) neuropsychological abilities assessed by the Category Test, (c) localization of function by the Category Test, (d) psychometric properties of the Category Test, (e) additional forms of the Category Test, (f) population

performance on the Category Test, and (f) computerization of the Category Test.

History of the Category Test

Halstead (1947) selected a series of seven tests based on their perceived power to differentiate patients with frontal neuropathology from either non-frontally involved patients or normal controls. One task, the Category Test, was 336 visually presented stimulus figures in which the subject's task was to abstract the underlying organizing principle. The initial 16 items enabled the subject to develop simple associations between Roman numerals and a number corresponding to one of four reaction keys. The individual learned in the sample test period that positive feedback followed correct responses and incorrect responses were followed by negative feedback. Throughout the remainder of the task the patient's task was to determine the organizing principle with either familiar or unfamiliar content. Failures on the Category Test resulted from a deficit in central integrative process, in that, poor performance was a result of failure in central integrative process rather than by an inability to group to criterion.

Reitan and Davison (1974) adapted the Category Test developed by Halstead (1947) for inclusion in their neuropsychological test battery. The Reitan and Davison (1974) version (CAT-208) consisted of seven sets of items with a total of 208 items. Organization of each set of

items was on the basis of an underlying principle such as number of objects, odd stimulus, ordinal position, or color (Spreen & Strauss, 1991). The basic purpose of the Category Test was to assess an individual's capacity to alter performance based on positive and negative feedback. The essential nature of the test was an experiment in abstraction or concept formation (Reitan & Wolfson, 1985; Spreen & Strauss, 1991). Thus, the CAT-208 required an individual to develop hypotheses about similarities and differences in stimulus materials and to change these hypotheses in accordance with positive or negative feedback (Reitan & Wolfson, 1985).

Hypothesized Neuropsychological Abilities Measured by the Category Test

Halstead (1947) considered the Category Test to be a measure of abstraction. Reitan and Davison (1974) noted that the test evaluated "concept formation and the ability to apply organizing principles in performance of complex procedures" (p. 58). The CAT-208 required an individual to assess a problem situation and then try to solve the problem by trial and error. The test does not require verbal abilities; rather, it demands flexibility in abstraction and concept formation.

Reitan and Wolfson (1985) and Spreen and Strauss (1991) reported that the CAT-208 required special competence in abstraction abilities. As a learning experiment in concept

formation, the CAT-208 demanded solution to a variety of problem situations. Golden, Osmon, Moses, and Berg (1981) noted that the CAT-208 measured an individual's ability to form, and confirm via experience, hypotheses. In addition to an assessment of intellectual potential, the test indirectly assessed frustration-tolerance level to negative feedback. The test also may measure visuospatial skills, attention, concentration, and simple counting skills.

Bertram, Abeles, and Snyder (1990) suggested that effective performance on the CAT-208 required skill in testing discrepancies among stimuli. In addition, the test tapped the capacity to incorporate feedback into planning, and a reasonable capacity for short-term memory. Rothke (1986) suggested that the CAT-208 not only required complex concept acquisition but it also assessed visual memory, visuospatial reasoning, and the ability to translate visual information into verbal output.

Boyle (1988) noted that the CAT-208 measured abstract concept formation, the ability to sustain attention, visuospatial skills, and learning. This was consistent with Nussbaum and Bigler (1989) who noted that the domains measured by the CAT-208 included nonverbal reasoning, learning, memory, and concept formation. Laatsch (1983) noted that the CAT-208 required metaknowledge, or "knowledge about knowledge." In that, the development of effective new decision making strategies required awareness of previous

strategies and their effectiveness or ineffectiveness with past stimuli.

Rattan, Dean, and Fischer (1986) reported that successful CAT-208 performance required two basic abilities: namely, integration of information within a perceptual field and psychomotor speed. In a study of 72 normal adult volunteers, speed of information processing or psychomotor speed explained 21% of the variability in the Halstead-Reitan Neuropsychological Battery (HRNB). Other than Tactile Performance Test Location scores (Reitan & Davison, 1974), useful predictors of CAT-208 errors were total response time and incorrect response time on the HRNB.

Glyshaw (1990) suggested that the CAT-208 and Wechsler Adult Intelligence Scale-Revised (WAIS-R, Wechsler, 1981) Picture Arrangement subtest measured the ability of the individual to plan and exercise judgement. In a study of 71 of 80 cases presented by Golden et al. (1981) no clear relationship between the CAT-208 and Picture Arrangement could be ascertained. It remains possible that both tests measured planning ability, but this ability accounted for only a small portion of the variance in one of both of the tasks. For example, while the Category Test measured planning ability it also may have measured adaptive ability or the ability to profit from experience. Picture Arrangement measured planning ability, but it also may assess the ability to appraise the whole of a situation.

Bertram et al. (1990) examined if the CAT-208 was a test of learning or the acquisition of new ways of organizing information and observational sets. Decrease in errors over time was the working definition of learning. In a sample of 159 inpatients referred for neuropsychological evaluation, learning was not a salient predictor of Category Test item errors. Although errors decreased over time on tests with multiple trials, learning did not affect item response behavior.

Localization of Function by the Category Test

The original purpose of the Category Test was to detect frontal lobe dysfunction (Halstead, 1947). Shute and Huertas (1990) hypothesized that Piagetian formal operational reasoning demonstrated frontal lobe development. In a study of 58 normal adults, these authors reported a strong relationship between a cognitive developmental measure and measures of frontal lobe dysfunction. The Piagetian Shadows Task was the measure of formal operational reasoning. Trails-Making Test, Part B (Reitan & Davison, 1974), Booklet Category Test (BCT, DeFilippis & McCampbell, 1979), and the Wisconsin Card Sorting Test (WCST, Heaton, 1981) were the measures of frontal lobe dysfunction. Individuals who negotiated the abstract reasoning demands of the Shadows Task also scored the highest on the measures of frontal lobe functioning. Thus, the ability to identify order among stimuli and to generate hypotheses from those

paradigms reflected adequate frontal lobe development or formal operational reasoning.

Kellner, Rubinow, and Post (1986) reported that ventricular brain ratio positively correlated with CAT-208 errors in a group of 21 depressed patients. However, age was a more salient predictor of CAT-208 errors and accounted for 48% of the variance. Ventricular brain ratio accounted for only 3.6% of the variance in the depressed patients. Therefore, the relationship between ventricular brain ratio and CAT-208 errors may merely be a product of the relationship between age and CAT-208 performance or ventricular brain ratio.

Despite its sensitivity to impaired brain functioning, however, the Category Test does not appear to either localize or lateralize neuropsychological function (Reitan & Davison, 1974; Reitan & Wolfson, 1985). Golden et al. (1981) suggested that the primary use of the CAT-208 was as an overall indicator of neuropathological conditions. Since the CAT-208 assessed a wide variety of neuropsychological skills, mediated by both right- and left-hemisphere, its best use was as an overall measure of cerebral dysfunction.

Bornstein (1986), in a sample of 53 brain-injured patients, reported no significant main effects for either laterality or caudality on the CAT-208. The CAT-208 was not specifically sensitive to frontal lobe dysfunction when compared to the Oral Fluency Task (Benton, 1968), Verbal

Concept Attainment Test (Bornstein & Leason, 1985), or the WCST. Instead, the CAT-208 appeared to measure a more general type of ability equally measured by the WAIS Verbal and Performance IQ.

Pendleton and Heaton (1982), in a study of 207 patients with structural cerebral lesions and 150 normal controls, reported that the WCST was more sensitive to frontal lesions. For the frontal group the WCST was diagnostically more accurate than the CAT-208. On the other hand, however, the CAT-208 was clinically more effective in the nonfrontal and diffuse cortical injury groups than the WCST. While similarity exists in the performance demands on the CAT-208 and WCST, the two tests were not interchangeable. If the two tests disagreed about the presence or absence of impairment, the CAT-208 was more accurate with the nonfrontal and diffuse subgroups. The WCST was more accurate with the frontal subgroup.

It is possible that poor performance on the WCST may be task, as opposed to diagnosis, related. Goldstein (1990), in a sample of 136 male schizophrenic inpatients, reported that 20% of the schizophrenics studied did not have problem-solving deficits. It was possible that the schizophrenics who performed well on the WCST demonstrated normal frontal lobe activation. Those schizophrenics who performed poorly did not have normal frontal lobe activation. Thus, the heterogeneity in problem-solving performance by

schizophrenic patients may represent a task-related activation failure compared to a diagnosis related activation failure. It is possible that task-related failure may have also affected patient performance and the results reported by Pendleton and Heaton (1982). Taylor, Goldman, Leavitt, and Kleinmen (1984) examined if the CAT-208 was sensitive to left- versus right-sided brain damage. In a sample of 168 male patients, the CAT-208 did not differentiate left- from right-sided brain damage.

In conclusion, although Halstead (1947), Kellner et al. (1986), and Shute and Huertas (1990) have suggested localization of brain damage by the CAT-208; others (Bornstein, 1986; Golden et al., 1982; Lansdell & Donnelly, 1977; Pendleton & Heaton, 1982; Reitan & Davison, 1974; Reitan & Wolfson, 1985; Spreen & Strauss, 1991) have noted that the CAT-208 does not localize or lateralize cerebral impairment. Use as a global indicator of neuropsychological performance was the primary purpose of the CAT-208.

Psychometric Properties of the Category Test

Reitan and Wolfson (1985) stated that the HRNB has "probably been researched in more detail than any other set of neuropsychological tests" (p. 10). While this may be the case, several problems plague the test battery. First, the HRNB does not have a theoretical base. Reitan and Davison (1974) developed the HRNB from the series of tests originally formulated by Halstead (1947) to detect frontal

lobe dysfunction. In contrast, the Luria-Nebraska Neuropsychological Battery (Golden, Hammeke, & Purisch, 1985) was theoretically derived from the work of A. R. Luria (1973). Second, the test battery lacks thoroughness in its treatment of memory, somatosensory, and praxic functions. Third, the battery is sensitive to the effects of aging and insensitive to the effects of small focalized lesions.

Fourth, intercorrelations between tests in the HRNB are unacceptably high. Some of the individual measures are better indicators of organicity than the HRNB as a whole. For example, Dodrill and Troupin (1975) suggested that the CAT-208, Tactile Performance Test - Localization, and the Impairment Index (Reitan & Davison, 1974) are the most sensitive Halstead measures to brain dysfunction. In isolation, these measures could predict the presence or absence of neuropsychological impairment. Swiercinsky (1978) also concluded that the intercorrelations between tests in the HRNB were unacceptably high. For example, in a sample of 567 referrals for neuropsychological evaluation, Swiercinsky (1978), in an attempt to pinpoint overlapping information in the HRNB, reported the following intercorrelation coefficients: (a) $r = .45$ between Seashore Rhythm and Speech-Sounds Perception, (b) $r = .41$ between Tactile Finger Recognition and the Reitan-Indiana Aphasia Screening Test and Speech-Sounds Perception Test, (c) $r = .43$ between Seashore Rhythm and Trails A, and (d) $r = .46$

and .45 between Grip Strength (Right and Left Hand) and Finger Tapping (Right and Left Hand).

Finally, the HRNB was unable to differentiate organic from psychogenic deficits such as those in chronic schizophrenia (Kolb & Whishaw, 1985). This was consistent with Lezak (1983) who noted that as "with all other psychological tests, prediction rates are less likely to be high when the discriminations to be made are between organic and psychiatric patients" (p. 565). Despite the limitations of the HRNB a wide variety of research has established the psychometric properties of the battery in general, and the CAT-208 in particular.

Factor analytic research. Shore, Shore, and Phil (1971), in a sample of 15 normal and 14 neurologically impaired subjects, examined the relationships among the seven subtests of the CAT-208 and four factors derived from the Wechsler Adult Intelligence Scale (WAIS, Wechsler, 1955). The CAT-208 produced correlations with verbal comprehension (.84), perceptual organization (.72), general intellectual functioning (.76), and memory (1.00). In contrast to Dodrill and Troupin (1975) these authors concluded that the CAT-208 could not determine neuropsychological impairment independently of intelligence.

Goldstein and Shelly (1972) tested the capacity of the HRNB to discriminate between brain-damaged and non-brain-damaged patients. In a sample of 619 subjects, these

authors identified four factors with the CAT-208 loaded significantly only on Factor 4. Factor 4 was analytic reasoning and consisted of tests that required problem-solving through which recourse to experience was not available. Factor 4 loaded on the CAT-208, Performance subtests of the WAIS, Tactile Performance Test - Speed, Memory, and Location, and Trail Making Test, Part B. The final matrix of four factors effectively discriminated 66.7% of left-hemisphere patients, 52.38% of right-hemisphere patients, 42.54% of patients with diffuse cortical injuries, and 65.38% of non-brain damaged patients. An Average Impairment Index of 1.92, correctly classified 69.98% of individuals with 36.25% false positives and 26.62% false negatives. Reduced accuracy of the four factors may, in part, be due to including psychiatric inpatients as the non-brain-damaged control group. Lin and Rennick (1974), in a sample of 239 epileptic patients, examined the relationship between the CAT-208, the WAIS subtests, factor scores, Verbal, Performance, and Full Scale IQ scores. The CAT-208 significantly correlated with every measure except age. In fact, significant correlations with the Verbal Factor ($r = .62$) suggested that the nonverbal properties of the CAT-208 may be questionable. This was consistent with Shore et al. (1971) who reported a similar relationship between the Category Test and the WAIS Verbal Factor.

Lansdell and Donnelly (1977) evaluated if the factors underlying the CAT-208 and Finger Oscillation (Reitan & Davison, 1974) were similar to the factors in the nonverbal subtests of the WAIS. In a sample of 59 psychiatric patients and 28 neurologically impaired subjects, this author identified four factors with the CAT-208 loaded significantly only on Factor 2 (.82). Factor 2 was a visuomotor factor and the results indicated that the Category Test was neither separate from nonverbal intelligence nor particularly sensitive to all types of brain pathology. The CAT-208 had a low loading on verbal comprehension, a finding in direct contrast to Lin and Rennick (1974) and Shore et al. (1971).

Swiercinsky (1979), in a sample of 1265 patients, described the functional abilities assessed by the HRNB. This author identified eight factors with the CAT-208 loaded significantly only on Factor 2. Tasks that required visual and nonvisual spatial understanding and object manipulation defined Factor 2. In addition to the CAT-208, the Tactile Performance Test and the Performance Scale of the WAIS loaded on this factor.

Yeudall, Reddon, Gill, and Stefanyk (1987), in a sample of 225 normal adults, reported few substantial correlations between the HRNB and the WAIS-R. The CAT-208 did correlate significantly and negatively with the Verbal Scale IQ ($r = -.34$) and the Performance Scale IQ ($r = -.29$). Boyle (1988)

examined, in a sample of 101 neurologically impaired individuals, what the CAT-208 measured. CAT-208 scores loaded significantly on a general cognitive-intellectual dimension, with additional loadings on both the WAIS-R Verbal and Performance IQ. Although the CAT-208 loaded on the general cognitive-intellectual factor, it was a more sensitive measure of neuropsychological dysfunction than the WAIS-R. For lateralization and localization purposes the WAIS-R was more effective than the CAT-208 (Bornstein, 1986; Golden et al., 1982; Lansdell & Donnelly, 1977; Pendleton & Heaton, 1982; Reitan & Davison, 1974; Reitan & Wolfson, 1985; Spreen & Strauss, 1991).

Corrigan and Hinkeldey (1988) investigated, in a sample of 532 adults, the factor analytic patterns among the HRNB measures used to assess levels of performance. Factor analysis identified six factors accounting for 96.5% of the variance with the CAT-208 loaded significantly only on Factor 4 (.59). Factor 4 represented active processing that was not language mediated and possibly integrative and reasoning capabilities. In addition to the CAT-208, the Wechsler Memory Scale (WMS) Figural Memory (Short-Term and Long-Term) (Wechsler, 1945), Speech-Sounds Perception Test, and Seashore Rhythm Test (Reitan & Davison, 1974) loaded on Factor 4.

Reliability. Matarazzo, Wiens, Matarazzo, and Goldstein (1974) examined the test-retest characteristics of

the HRNB. Test-retest coefficients in 16 patients with cerebrovascular disease on the CAT-208 was .96; while, in a sample of 29 normal subjects the test-retest coefficient was .60 (significant at $p < .001$). Matarazzo, Matarazzo, Wiens, Gallo, and Klonoff (1976) reported the test-retest reliability coefficients for the HRNB. On the CAT-208 the test-retest coefficients were .60 for the sample of 29 normal males, .72 for the 35 chronic schizophrenics, .82 for the sample of 15 patients post carotid endarterectomy, and .96 for the 16 patients with diffuse cerebrovascular disease. Examination of CAT-208 scores on retest showed a better mean performance for the normal and schizophrenic samples but no such improvement in either organic group. Failure to improve retest scores on the CAT-208 may help in clinically differentiating organic from nonorganic status.

Dodrill and Troupin (1975) reported similar practice effects on the CAT-208. In a sample of 17 epileptics with stable neurological conditions, practice effects occurred on the three Halstead measures that are most sensitive to neurological dysfunction: the Category Test, Tactile Performance Test - Location, and the Impairment Index. With repeated administrations, Dodrill and Troupin (1975) warned that changes in test scores had significant clinical implications.

In a sample of 285 patients, Moses (1985) reported a coefficient alpha of .96 for the 208 items of the Category

Test. For Subtests 3-6 coefficient alpha was .90. With a k statistic correction to insure equivalency of 40 items, the estimated coefficient alpha was .78 for Subtest 1, .62 for Subtest 2, and .81 for Subtest 3. Sarazin and Spreen (1986) examined the test-retest characteristics of the Wechsler Intelligence Scale for Children (WISC, Wechsler, 1949), Wide Range Achievement Test (WRAT, Jastak & Jastak, 1965), the Category Test (Shortened Intermediate Form), Sentence Repetition (Benton & Hamsher, 1983), Benton Right-Left Orientation (Benton, 1959), Lateral Dominance (Harris, 1947), and Motor Grip Strength (Reitan & Davison, 1974). In a sample of 175 children divided into three diagnostic groups (definite neurological dysfunction, minimal brain dysfunction, and learning disabled without neurological involvement), test results for the brain damaged group showed the highest degree of stability. Psychometric intelligence did not affect the stability of scores from test to retest. All groups, at both ages, made more errors on the Category Test than the normative group.

Charter, Adkins, Alekoumbides and Seacat (1987) addressed the reliability of the WAIS, WMS, and several subtests of the HRNB (e.g., the CAT-208, Tactile Performance Test, Speech-Sounds Perception Test, Seashore Rhythm, and Finger Oscillation). In a sample of 311 adults, these authors reported an uncorrected split-half reliability coefficient of .97 with a standard error of estimate of 5.01

for the CAT-208. A corrected score of .95 with a standard error of estimate of 3.21 was helpful for standardization and in the determination of confidence limits.

Relationship of the Category to other Neuropsychological Measures

Pendleton and Heaton (1982) examined if the WCST and the CAT-208 were interchangeable. In a sample of 207 patients with structural cerebral lesions and 150 normal controls, the WCST and the CAT-208 correlated at .56 for the brain-damaged group and .55 for the normal controls. In addition, the WAIS Full Scale IQ correlated with the CAT-208 at -.57 for the brain-damaged group and -.47 for the normal controls. WAIS Full Scale IQ correlated with the WCST at -.42 for the brain-damaged group and -.36 for the normal controls. While the two tests appear related, the CAT-208 and the WCST were not clinically interchangeable. This was especially true if localization was necessary. For example, the WCST was more accurate in identifying frontal lesions, while the CAT-208 was more accurate in identifying nonfrontal focal or diffuse lesions. Bond and Buchtel (1984) compared the WCST and the CAT-208 and noted that the perceptual-abstraction demands required by the CAT-208 were more difficult than those of the WCST.

Brandon and Chavez (1985) assessed the effects of administration order between the WCST and the CAT-208. In a sample of 72 college students, an order effect occurred if

the CAT-208 was the first test administered. For example, a reduction in perseverative responses and total error score occurred on the WCST if the CAT-208 was given first. However, Rothke (1986) reported no main effect for order of test administration in a sample of 72 inpatients. In addition, set shifting cues only affected performance on the WCST; in that, including cues decreased the number of perseverative responses on the WCST. Despite set-shifting cues, however, the correlation between the CAT-208 and the WCST did not increase. Thus, the CAT-208 and the WCST measured distinct cognitive abilities and were not equivalent measures (Pendleton & Heaton, 1982).

Tupper (1990) examined the relationship between severity of illness (coma duration) and the Woodcock-Johnson Psychoeducational Battery - Test of Cognitive Ability (WJPB-TCA, Woodcock & Mather, 1989) and several HRNB measures. Severity of injury did not correlate with any of the WJPB-TCA cluster scores. In addition, no significant correlations occurred between the CAT-208 and WJPB-TCA cluster scores. Tupper (1990) noted that the WJPB-TCA, the Wechsler Performance IQ, and the CAT-208 were not clinically interchangeable. Patients in this study, however, did show deficits on tasks that tapped fluid intelligence. For example, low scores on Spatial Relations, Visual Matching, Visual-Auditory Learning, Analysis-Synthesis, and Concept Formation reflected deficits in fluid intelligence. This

was consistent with Cullum, Steinman, and Bigler (1984) and Cullum, Kuck, and Ruff (1990) who reported similar relationships between cerebral dysfunction and fluid abilities. For example, Cullum et al. (1984) examined the relationship between fluid and crystallized abilities using the WAIS and the CAT-208. In a sample of 22 patients with left-hemisphere damage, 20 patients with right-hemisphere damage, and 50 patients with diffuse cortical injuries the CAT-208 correlated ($r = -.52$) significantly with the WAIS Performance IQ. Since both measures assessed fluid abilities, as opposed to overlearned crystallized abilities, this finding was not unexpected. Cullum et al. (1990) also noted that cerebral dysfunction affected tasks that tap fluid abilities more than tasks that assessed crystallized abilities.

Ryan, Rosenberg, and Prifitera (1983) compared predicted CAT-208 scores based on WAIS-R and WAIS scores. In a sample of 70 patients with either neurologic or psychiatric impairment, patients with a given WAIS-R Full Scale IQ performed better on the Category Test than a patient with an equivalent WAIS Full Scale IQ. Therefore, same scores on the WAIS-R and WAIS represented different cognitive abilities and predicted CAT-208 performance based on the two intelligence scales differed.

Additional Forms of the Category Test

One of the major drawbacks of the CAT-208 is the time required for administration (Calsyn, O'Leary, & Chaney, 1980). This offers one explanation for why Reitan and Herring (1985) omitted the CAT-208 from their screening battery for children. There is disagreement, however, that the CAT-208 requires a lengthy administration time. Finlayson, Sullivan, and Alfano (1986) considered the criticism of excessive time for administration of the CAT-208 as unwarranted. In a sample of 79 severely head injured inpatients and 66 patients referred for neuropsychological evaluation, 93% of patients completed the test in 1 hour. In addition, 50% completed the tests in less than 40 minutes. Only 7% of patients required more than 1 hour to complete the CAT-208.

Equipment cost and bulk have also been criticisms of the CAT-208 (Slay, 1984). Kupke (1983), in a sample of 80 college students, investigated the effects of standard versus portable equipment on the CAT-208. Tasks that required complex cognitive processing, such as the CAT-208, were robust to alterations in instrumentation. However, Reitan and Wolfson (1985) warned that altered or abbreviated forms of the CAT-208 lacked experimental and clinical validation. Despite this warning, several researchers have tried to reduce the length (and bulk of equipment) of the CAT-208 while maintaining adequate reliability and validity.

Short forms of the Category Test. Kilpatrick (1970) first considered the feasibility of a short form of the CAT-208. In a sample of 41 patients, reported correlation coefficients for the total error score to the error score for odd items were .90, .99 for the total to even items, and .97 for the odd items to even items. With removal of 104 items from the CAT-208 a reliability coefficient of .94 was possible. Boyle (1975) developed an abbreviated form of the CAT-208 based on the work of Kilpatrick (1970). In this revision, Subtests 1, 2, 3, 4, and 7 consisted of half their original items. Twenty items from a combination of Subtests 5 and 6 made up the final subtest. A total of 84 items made up the Boyle (1975) revision. In a sample of 16 brain damaged patients and 35 normal controls, the results showed that the short form differentiated significantly the two groups. With a cutoff of 38 errors, misclassifications occurred for 6% of the brain damaged group and 22% of the normal control group. The 20 items of Subtests 5 and 6 did not discriminate adequately between the two groups. Therefore, future revisions could drop these twenty items. Overall this short form required only 15 minutes to administer and was an adequate substitution for the CAT-208. Boyle (1986) examined the Boyle (1975) short form and the CAT-208. In a sample of 16 brain damaged and 35 normal controls, a cutoff point of 38 errors misclassified 6% of the brain damaged patients and 22% of the non-brain-damaged

controls. This showed that the Boyle (1975) short-form significantly differentiated brain-damaged from non-brain-damaged individuals. Again, further reduction from 84 to 64 items was possible without loss of discriminative power.

Gregory, Paul, and Morrison (1979) proposed a 120 item version (CAT-120) of the CAT-208. In this revision, Subtest 1 contained only 8 items with Subtests 6 and 7 omitted in their entirety. Subtest 2 consisted of the first 16 items, and Subtests 3, 4, and 5 included the first 32 items in each subtest. In a sample of 18 patients with neurological impairment and 52 normal controls, the correlation coefficient between the CAT-208 and the CAT-120 was .95. Both tests correctly identified 78% of the neurologically impaired group. The CAT-208 misclassified one subject but the CAT-120 did not misclassify a single subject. Time reduction in administration was between 30 to 35 minutes.

Calsyn et al. (1980) examined the utility of using an error score derived from the first four subtests of the CAT-208. In a sample of 150 male alcoholics, reported correlation coefficients were .89 in the validation phase and .88 in the cross-validation phase. With a cutoff of 51, the Calsyn et al. (1980) short form (CAT-108) misclassified only 14% of individuals in the validation phase and 8% in the cross-validation phase. Since the first four subtests accounted for 77% to 79% of the total variance of the CAT-208, an abbreviated form based on these four subtests

provided an adequate estimate of the total score. Taylor, Hunt, and Glaser (1990) cross-validated the CAT-108 to determine if the long form and the short form detected left- and right-sided brain-damage. In a sample of 168 right-handed patients, the correlation coefficient between the predicted and actual CAT-208 scores and CAT-108 scores was .91. Use of the CAT-108 misclassified 63% of the normal controls. The actual CAT-208 error score misclassified only 30% of normal controls. Neither the abbreviated nor the long form of the CAT-208 differentiated left- and right-sided brain damage. Moses (1985) compared the reliability coefficients for the CAT-108 and the CAT-208 in a sample of 285 patients. Coefficient alpha for the CAT-108 was .95 and .96 for the CAT-208. The stability and accuracy of the CAT-108 was comparable to that of the CAT-208. Thus, the CAT-108 was internally consistent and an adequate approximation of the full form of the Category Test.

Dunn, Margolis, and Taylor (1985) investigated the utility of the CAT-108 abbreviated form in a geriatric population. In a sample of 60 neurologically impaired geriatric patients correct classifications occurred in 100% of the mildly impaired, 56% of the moderately impaired, and 77% of the severely impaired patients in the validation phase. In the cross-validation phase correct classification occurred in 67% of the mildly impaired, 60% of the moderately impaired, and 86% of the severely impaired

patients. In this sample, the reported correlation coefficient between the CAT-208 and the CAT-108 was .83. The abbreviated form was an adequate indicator of gross level of performance. However, accuracy in prediction suffered with the use of the CAT-108.

Sherrill (1985) assessed the reliability of the CAT-120 and the CAT-108 with 100 consecutive referrals for neuropsychological evaluation. The correlation coefficients were as follows: (a) .98 for the CAT-208 and the CAT-120, (b) .94 for the CAT-208 and the CAT-108, and (c) .96 for the CAT-120 and the CAT-108. The CAT-120 correlated the highest with the CAT-208 ($r = .98$) and had the lowest standard error of estimate (± 7.5), compared to the CAT-108 correlation with the CAT-208 ($r = .94$) and standard error of estimate (± 12.9). Since the two versions correlated highly with one another ($r = .96$) both appeared to measure the same construct. However, the higher correlation with the CAT-208 and lower standard error of estimate of the CAT-120 indicated that this was clinically the more effective abbreviated form. Sherrill (1987) compared the CAT-108, the Victoria Revision (Labreche, 1983 cited in Spreen & Strauss, 1991), and a revision of the Victoria Revision to the CAT-208. The Victoria Revision retained the first 5 items of Subtest 2, the first 24 items of Subtests 3 and 4, the first 17 items of Subtest 5, and items 7 to 22 of subtest 6. Labreche (1983) dropped Subtests 1 and 7 in the Victoria

Revision. In the revised Victoria Revision, Sherrill (1987) retained the first 5 items of Subtest 2, the first 24 items of Subtests 3 and 4, and the first 17 items of Subtest 5. Sherrill (1987) dropped Subtests 1, 6, and 7. in the revised Victoria Revision. In a sample of 35 neuropsychological referrals, the correlation coefficients were as follows: (a) .96 for the CAT-208 and the CAT-108, (b) .95 for the CAT-208 and the Victoria Revision, and (c) .92 for the CAT-208 and the revised Victoria Revision. The Victoria Revision was superior in administration time and predictive accuracy. However, the CAT-108 also provided good predictive accuracy but administration time increased with the additional 39 items. Clinical cutoffs for the CAT-108 was 29 and 26 for the Victoria Revision.

Summers and Boll (1987) investigated the relationship between the booklet short form of the Category Test (Wetzel & Boll, 1987) and the CAT-208. In a sample of 50 undergraduates, corrected split-half reliability coefficients were .89 for the CAT-208 and .81 for the booklet short form. However, order of administration significantly affected these results. For example, the correlation coefficient between the CAT-208 and the booklet short form was .93 with the CAT-208 administered first; however, administration of the booklet short form first caused the correlation coefficient to drop to .66. Despite this limitation, the booklet short form (Wetzel & Boll,

1987) was an acceptable alternative to the CAT-208. Total administration was 10 minutes with a substantial reduction in time required to score the test.

Russell and Levy (1987) shortened the CAT-208 and reorganized Subtests 5 and 6. In this revision (RCAT), subtest composition was as follows: (a) Subtest 1 reduced to five items, (b) Subtest 2 reduced to 10 items, (c) Subtests 3 and 4 reduced to 20 items apiece, and (d) Combination of Subtests 5 and 6 reduced to Subtest A for pure counting quantity and Subtest B for complex counting quantity. The RCAT dropped Subtest 7. To derive an equivalent long form score, these authors used a linear extrapolation of RCAT (error score) multiplied by 2.2. In a sample of 95 brain-damaged patients and 25 normal controls, the RCAT and CAT-208 correlated at .97. With a prorated cutoff of 50, the RCAT correctly classified 63% of brain-damaged patients, 84% of the normal controls, for a total predictive accuracy of 80%. In contrast, the CAT-208 correctly classified 82% of the brain-damaged patients, 63% of the normal controls, for a total predictive accuracy of 78%. Thus, the RCAT was a suitable alternative to the CAT-208.

Taylor et al. (1990) compared the RCAT, the CAT-120, and the CAT-108 with the CAT-208. In a sample of 294 male neuropsychological evaluation referrals, the correlation coefficients were as follows: (a) .96 for the CAT-208 and

the RCAT, (b) .97 for the CAT-208 and the CAT-120, (c) .91 for the CAT-208 and the CAT-108. The correlation coefficient of .96 compared favorably to the .97 correlation coefficient reported by Russell and Levy (1987). The RCAT and the CAT-120 were better predictors of CAT-208 error scores. However, the linear extrapolation suggested by Russell and Levy (1987) overestimated individual errors on the CAT-208 (Taylor et al., 1990).

Vanderploeg and Logan (1989) criticized the RCAT on three points: First, the RCAT reduced the number of perceptual shifts required by the CAT-208. If the RCAT reduced the number of perceptual shifts (a frontal lobe function, Russell & Levy, 1987) then the RCAT no longer measured the same construct as the CAT-208 (Vanderploeg & Logan, 1989). Russell and Barron (1989) contended that the shifts across perceptual dimensions on the CAT-208 were of minor importance. Instead, the crucial difference was in conceptual shifts required by the CAT-208. It was possible, according to Russell and Barron (1987) that the reduced accuracy of the CAT-108 was due to a reduction in conceptual shifts (subtests) without a reduction in perceptual shifts (length of retained subtests). Russell and Levy (1987) avoided this problem in the RCAT (Russell & Barron, 1989). Second, Vanderploeg and Logan (1989) noted that Russell and Levy (1987) did not establish alternate form reliability and criterion-related validity. To date, however, no research

has established alternate form reliability for the CAT-208. The criticism of inadequately established criterion-related validity appears unwarranted. The RCAT has a clearly established criterion (Anastasi, 1988) namely, the presence or absence of neuropsychological dysfunction, and performed equally well as the CAT-208 in differentiating brain-damaged patients from non-brain-damaged controls (Russell & Levy, 1987; Taylor et al., 1990). Finally, Vanderploeg and Logan (1989) criticized the linear extrapolation established by Russell and Levy (1987) since it assumed that all items in the CAT-208 were of comparable levels of difficulty. Taylor et al. (1990) also criticized the RCAT linear extrapolation because, in their sample, it overestimated CAT-208 error scores. However, Russell and Barron (1989) reported that a RCAT score of 10 predicted a CAT-208 score of 10.99 and a RCAT score of 140 predicted a CAT-208 score of 139.6.

Booklet Category Test. DeFilippis and McCampbell (1979) developed a booklet form of the CAT-208. Method of administration was the major change between the CAT-208 and the BCT. Other minor changes included instructions for administration and a score sheet depicting the test items. McCampbell and DeFilippis (1979) investigated the relationship between the BCT and the CAT-208. In a sample of 30 normal college students, the reported overall correlation coefficient was .91. For those who received the CAT-208 first, the correlation coefficient was .89. For

those who received the BCT first, the correlation coefficient was .94. A significant practice effect occurred between the initial and second administration of the Category Test. However, order of test version was not significant. DeFilippis, McCampbell, and Rogers (1979) examined the relationship between the BCT and the CAT-208 in a sample of 30 chronic alcoholics. The reported overall correlation coefficient was .80. In the sample of alcoholics, for those who received the CAT-208 first, the correlation coefficient was .82. For those who received the BCT first, the correlation coefficient was .75. In addition to a significant practice effect, order of test version was significant. Alcoholics who received the BCT initially had lower mean scores than did alcoholics who received the CAT-208 initially.

MacInnes, Forch, and Golden (1981) cross-validated the BCT (DeFilippis & McCampbell, 1979). In a sample of 38 male inpatients divided into three diagnostic categories (organic brain syndrome, schizophrenia without evidence of organicity, and personality disorder), the correlation coefficients between the CAT-208 and the BCT were as follows: (a) .78 for the organic brain syndrome group, (b) .52 for the schizophrenic group, and (c) .94 for the personality disorder group. The high correlation with the CAT-208 ($r = .74$) showed that, without loss of reliability or validity, the BCT was an adequate substitute for the CAT-

208. However, the BCT did not reliably measure the performance of schizophrenics. This may be sample related since test reliability is typically lower in patient populations (DeFilippis & McCampbell, 1979).

The Category Test With Specific Populations

Corrigan, Agresti, and Hinkeldey (1987) investigated the relationship between etiology of head trauma (closed head injury versus cerebrovascular accident) and CAT-208 errors. In a sample of 102 patients, etiology of injury did not affect CAT-208 performance. The correlation between the CAT-208 and WAIS-R Performance IQ was $-.64$. The correlation between the CAT-208 and the WAIS-R Verbal Scale IQ was $-.11$. These results were consistent with Cullum et al. (1984), Lansdell and Donnelly (1979), and Swiercinsky (1979) who noted similar relationships between the CAT-208 and the WAIS/WAIS-R Performance and Verbal Scale IQs. However, the results contrast the reports of Lin and Rennick (1979), Shore et al. (1971), and Yeudall et al. (1987) who reported opposite relationships between the CAT-208 and the WAIS/WAIS-R Performance and Verbal Scale IQs. In contrast to Tupper (1990) and Cullum et al. (1984), however, Corrigan et al. (1987) noted that the CAT-208 and the WAIS-R Performance subtests captured different phenomena. For example, the CAT-208 and WAIS-R Performance Scale differed about lateralization and the abilities required for visual-spatial processing and motor speed.

Leininger, Gramling, Farrell, Kreutzer, and Peck (1980) examined whether minor head injuries accompanied by a loss of consciousness (less than 20 minutes) produced similar neuropsychological deficits to injuries that resulted in no loss of consciousness. In a sample of 76 patients (31 with minor head injuries, 22 who experienced no loss of consciousness, and 23 controls), subjects who experienced a minor head injury scored significantly poorer on five neuropsychological tests. Poor performance occurred on the CAT-208, Paced Auditory Serial Addition Test - Revised (Gronwall, 1977), Auditory Verbal Learning Test (Rey, 1964), and the Complex Figure Test - Memory and Copy (Rey, 1941). However, no significant differences emerged between the mild concussion and no-concussion group on any of the tests. Injuries associated with a brief loss of consciousness were not more debilitating than injuries associated with no formal loss of consciousness. The presence or absence of a traumatic loss of consciousness did not delineate individuals at greater or reduced risk for neuropsychological deficits. This was consistent with Bigler (1990) who reported that alterations in level of consciousness was not a "necessary or sufficient condition to define the presence of brain injury" (p. 14) or the risk for neuropsychological impairment.

Davidoff, Morris, Roth, and Bleiberg (1985) examined the relationship between traumatic spinal cord injury and

cognitive dysfunction. In a sample of 30 patients, 57% had abnormal CAT-208 scores indicative of cognitive dysfunction. This suggested that cognitive deficits may occur in the 8 to 12 weeks following a traumatic spinal cord injury. Roth, Davidoff, Thomas, Doljanac, Dijkers, Berent, Morris, and Yarkony (1989) investigated the performance of acute spinal cord patients on a motor-free neuropsychological test battery. In a sample of 81 acute spinal cord injury patients and 61 normal controls, impaired performance occurred for spinal cord injured patients on the CAT-208, WAIS-R Vocabulary subtest, WMS Mental Content, Logical Memory, and Paired Associates, and the Auditory Verbal Learning Test. On the CAT-208, spinal cord injured patients scored a mean of 57.3 (SD = 3.4) which showed a compromise in the ability to adapt to new situations or shift mental sets. History of a premorbid or concurrent closed head injury affected test scores; in that, spinal cord patients without a concurrent or premorbid closed head injury were slightly less likely to have abnormal scores than patients with a premorbid or concurrent closed head injury.

Goldstein and Zubin (1990) examined age differences among schizophrenics with and without neurological dysfunction and normal controls on the HRNB. In a sample of 579 schizophrenics and 240 normal controls, schizophrenics did not differ from normals on tasks that typically deteriorate with age or acquired brain injury. Complex

cognitive tasks such as the Category test typically deteriorate with age. However, schizophrenia coupled with neurological dysfunction resulted in a deterioration of skills mediated by sociocultural stimulation (WAIS Comprehension and Information subtests). Goldstein (1990) examined the abstraction and problem solving abilities of 136 male schizophrenic inpatients via cluster analysis of scores from the CAT-208, Tactile Performance Test, Trail-Making Test - Part B, and the WCST. This author identified five clusters with only Cluster 4 performing poorly on the Category Test. Cluster 4 had the second highest percentage of neurological comorbidity and a test profile characterized by poor performance on the CAT-208, Tactile Performance Test, and Trail-Making - Part B. While the results revealed heterogeneity of problem-solving in schizophrenia, those schizophrenics that had a high degree of neurological comorbidity (e.g., Clusters 3 and 4) performed poorly on the measures chosen.

Barnes and Lucas (1974) examined the relationship between personality dysfunction and performance on the HRNB. In a sample of 77 brain-damaged subjects and 39 subjects with personality dysfunction but no organicity, differences between the two groups were significant except on the Seashore Rhythm Test and Time Sense Memory (Reitan & Davison, 1974). However, with age and IQ covaried all separations between organic and psychogenic groups

disappeared. This contrasts Matarazzo et al. (1976) who reported that test-retest stability differentiated organic from psychogenic involvement. Barnes and Lucas (1974) recommended, with patient age, the Seashore Rhythm Test, Time Sense Memory, Tactile Performance Test, Finger Oscillation, and the Aphasia Screening Test (Reitan & Wolfson, 1985) to differentiate organicity from nonpsychotic psychological impairment.

Everett (1984) investigated the relationship between hepatic function and cognitive function in a sample of 20 alcoholic patients. Forty-seven percent of the sample had abnormal γ -glutamyl transpeptidase levels and 63% had abnormal CAT-208 scores. A negative correlation occurred between γ -glutamyl transpeptidase levels and CAT-208 error scores. In that, subjects with evidence of cognitive deficits (high error score on the CAT-208) had normal liver function or low γ -glutamyl transpeptidase levels. In the later stages of alcoholism, after permanent damage to the liver and its ability to metabolize alcohol, cognitive deficits may begin to develop with the damaged liver failing to display evidence of enzyme induction.

Hesselbrock, Weidenman, and Reed (1985) examined the effects of age, sex, drinking history, and the presence or absence of antisocial personality on the Brain Age Quotient and subtest scores of alcoholics. Derived from scores on the HRNB (CAT-208, Tactile Performance Test, Trail-Making -

Part B) and the WAIS (Digit Symbol and Block Design) the Brain Age Quotient (BAQ) has a mean of 100 and a standard deviation of 15. In a sample of 244 inpatient alcoholics, scores on the HRNB and the BAQ showed evidence of moderate levels of impairment. This was consistent with Reitan and Wolfson (1985) who noted that chronic alcoholics have adequate IQ values but showed considerable impairment on the four tests sensitive to organicity (the Impairment Index, the CAT-208, Trail-Making Test - Part B, and the localization component of the Tactile Performance Test). In contrast to Reitan and Wolfson (1985), Hesselbrock et al. (1985) noted that age was the most salient factor affecting test performance. For example, older alcoholics (aged 40 years and older) displayed mild to moderately severe levels of impairment. Younger alcoholics (under 40 years of age) performed at the lower end of the normal range. The presence of an antisocial personality disorder interacted with sex to affect performance on Block Design and the CAT-208. Males with antisocial personality disorders performed at higher levels than females with antisocial personality disorder. This may be a sampling artifact due to the few females, in this sample, with an antisocial personality disorder (5%).

Ernst (1987) investigated the performance of elderly subjects (aged 65 to 75) on three tests of adaptive problem solving (Trail Making Test, Tactile Performance Test, and

the BCT). In a sample of 110 healthy elderly adults, the established cutoff of 51 errors was inappropriate. Ernst (1987) recommended a cutoff of 66.7 for elderly males and 83.3 for elderly females on the BCT.

Willis, Yeo, Thomas, and Garry (1988) examined the relationship between health status and the decline of memory and executive cognitive skills in elderly individuals. In a sample of 154 elderly subjects, only health status predicted performance on the CAT-208. Age affected scores on the WMS Logical Memory and Visual Reproduction subtests. Thus, while memory skills (temporal and limbic structures) displayed progressive decline with aging, mental flexibility in problem-solving remained intact much later in life. The decline in executive cognitive skills may be due to differing health status; in that, the decline in executive skills (as measured by the CAT-208) may be more indicative of the prevalence of illness than of age-related brain changes.

Horton and Siegel (1990) compared the performance of patients with multiple sclerosis to those with an acquired head trauma on a battery of neuropsychological tests. In a sample of 4 patients with multiple sclerosis and 4 patients with head trauma, significant differences emerged between the two groups on all test variables. The strongest differences occurred on the CAT-208, the WMS, and Trail-Making Tests. Both groups had difficulties in concept

formation, but the head trauma group displayed significantly greater neuropsychological impairment. This was consistent with Golden et al. (1981) who noted that patients with multiple sclerosis typically showed cognitive deficits on the brain-damage sensitive tests of the HRNB (CAT-208, Tactile Performance Tests - Total Time and Location, Digit Span, and Digit Symbol).

Skenazy and Bigler (1984) examined the neuropsychological test performance of diabetic patients with duration and severity of illness controlled. In a sample of 39 Type 1 diabetics, 20 healthy control subjects, and 20 chronic illness patients, the diabetic patients showed greater sensory deficits than nondiabetic controls. The pattern of errors indicated peripheral nerve damage (e.g., tactile extinctions) consistent with peripheral sensory neuropathy, an early complication of diabetes. Consistent with Willis et al. (1988) a significant relationship existed between duration of illness and CAT-208 errors ($r = -.38$). Anxiety experienced by patients with a chronic illness (Skenazy & Bigler, 1984) or the prevalence of illness experienced by these diabetic patients were possible explanations for the relationship between duration of illness and CAT-208 errors (Willis et al., 1988). In contrast to Hesselbrock et al. (1985), age was not a significant factor in neuropsychological test performance (Skenazy & Bigler, 1984).

Cuevas and Osterich (1990) examined the error scores on the BCT for individuals from various countries. In a sample of 26 adults with English as their first language and 105 adults in which English was not their first language, the results showed a significant main effect for sex and an interaction effect for sex and language. European females produced significantly higher error scores on the BCT than did males. There was no difference in error scores between American males and females and European males. Thus, the BCT appeared applicable for non-English speaking populations.

Automation and the Category Test

With the beginning of microcomputers the use, and possible misuse, of computer based testing and interpretation has generated extensive debate (Adams & Heaton, 1985; Adams, Kvale, & Keegan, 1984; Anthony, Heaton, & Lehman, 1980; Heaton & Adams, 1987; Heaton, Grant, Anthony, & Lehman, 1981; Kleinmuntz, 1987; Knights & Watson, 1968; Moerland, 1985). Adams and Heaton (1987) concluded that the clinical deployment of computer based interpretative programs for neuropsychology would be premature and potentially unethical. The lack of agreement about diagnostic decision tasks and failure to incorporate demographic variables (sex, age, education, etc.) that effect neuropsychological performance into existing interpretation programs were the basis of Adams and Heaton's

(1987) conclusion. Kleinmuntz (1987), on the other hand, stated that the computer was "exquisitely equipped for clinical decision making strategies because the machine is a noncomputational rather than a computational tool and because most expert and novice clinicians decisions can be articulated" (p. 266). The problem was not in the format or nature of the data but in the need to formulate programs that capture the computer's processing capabilities. While the debate about interpretative programs may continue indefinitely, considerable efforts toward setting up computerized tests has occurred. Advantages to computerized testing are convenience, economy, objectivity (Moerland, Aldenkamp, & Alpherts, 1986), and the provision of consistent, clear, and instant feedback for the examiner and examinee (Lynch, 1985).

Moerland et al. (1986) developed a neuropsychological test battery for the Apple II-E computer. Included in this automated battery was Digit Span, Simple Reaction Time, Binary Choice Reaction Time, Vigilance Test, Corsi Block Tapping Test, Visual Searching, Finger Tapping, Iconics Test, Visual Half-Field Test, Seashore Rhythm Test, Fifteen Words Test, and the Recognition Test. These authors reported little patient resistance to this computerized neuropsychological battery.

Morrison and Gates (1988) evaluated the equivalence of a computerized version of the Austin (Milner) Maze with the

original version (Walsh, 1978). In a sample of 32 male computer science students, correlations between the two forms were not significantly different. Thus, the computerized version was an adequate substitute for the more tedious traditional form. Collins and Odell (1986) compared a computerized version of Raven's Coloured Progressive Matrices with the original booklet version (Raven, 1965). In a sample of 16 aphasic patients, no reported differences in reaction time, error type, or problem type occurred. The computerized version did not appear to change the visual processing demands of the original version. Although some complaints surfaced about mechanization, the ease of administration, data collection, and analysis clearly suggested that the computerized version was a useful alternative to the traditional booklet format.

Beaumont (1975) first investigated the validity of administering the CAT-208 via an on-line computer. In a sample of 10 psychiatric patients and 10 brain-damaged patients, the results showed that the two groups did not differ in performance on the CAT-208. With a cutoff of 50 errors, the on-line CAT-208 misclassified 70% of the psychiatric group, 30% of the brain-damaged group, for a total misclassification rate of 50%. These findings were consistent with Goldstein and Shelly (1972) who used a traditional administration of the CAT-208.

Miller (1989) developed a computerized version of the Category Test using Hypercard™ software for the Macintosh computer. In a comparison of the Intermediate BCT and the Computerized Version of the Category Test (CV-CAT), no significant differences emerged between the two versions for total errors or subtest errors. However, completion time was significantly longer for the CV-CAT than for the BCT. This difference may have resulted in the time required for the individual to acclimate to the mouse pointer in the Computerized Version.

Purpose

Psychometrically, the CAT-208 (Reitan & Wolfson, 1985) has more than adequate reliability and validity (Anastasi, 1988). Test-retest reliability coefficients range from .60 for normals to .96 for neurologically impaired individuals (Matarazzo et al., 1974; Matarazzo et al., 1976; Sarazin & Spreen, 1986). Split-half reliability coefficients range from .94 (Kilpatrick, 1970) to .97 (Charter et al., 1987). Coefficient alpha was .96 (Moses, 1985). Research has also examined the psychometric properties of alternate or abbreviated forms of the CAT-208 (Boyle; 1975, 1986; Calsyn et al., 1980; DeFilippis & McCampbell, 1979; DeFilippis et al., 1979; Dunn et al., 1985; Gregory et al., 1979; Kilpatrick, 1970; MacInnes et al., 1981; McCampbell & DeFilippis, 1979; Moses, 1985; Russell & Levy, 1987; Sherrill, 1985; Sherrill, 1987; Summers & Boll, 1987; Taylor

et al., 1984; Taylor et al., 1990). Also, little doubt exists that the Category Test is a sensitive measure of neuropsychological impairment (Boyle, 1988; Dodrill & Troupin, 1975; Golden et al., 1981; Reitan & Davison, 1974; Reitan & Wolfson, 1985; Spreen & Strauss, 1991). To date little research has examined the psychometric properties of full, alternate forms of the CAT-208 and their use in neuropsychological assessment (MacInnes et al., 1981). In addition, little research exists comparing the performance of brain-injured versus non-brain-injured individuals on full, alternate forms of the CAT-208 (MacInnes et al., 1981). Therefore, the first purpose of the present study is to examine the performance of brain-injured and non-brain-injured individuals on the CAT-208 (Reitan & Wolfson, 1985), the BCT (DeFilippis & McCampbell, 1979), and the CV-CAT (Miller, 1989). Specifically, the goal is to show criterion-related validity for the CAT-208 (Reitan & Wolfson, 1985), the BCT (DeFilippis & McCampbell, 1979), and the CV-CAT (Miller, 1989). The criterion, in this study, will be the presence of neuropsychological dysfunction.

Other than the warning by Ryan et al. (1983) about the discrepancy between WAIS and WAIS-R scores, little research has examined the relationship of the CAT-208 to the Wechsler Adult Intelligence Scale - Revised (Davidoff et al., 1985; Roth et al., 1989; Yeudall et al., 1987). Only Corrigan et al. (1987) have examined the relationship between the CAT-

208 and the WAIS-R in a sample of closed head injured patients. In addition, no research has examined the relationship between the CAT-208 and the WAIS-R as a Neuropsychological Instrument (WAIS-R NI, Kaplan, Fein, Morris, & Delis, 1991). Therefore, the final purpose of the present study is to examine the relationship between the WAIS-R NI and the Category Test and how the presence or absence of a head injury affects this relationship.

Based on a review of the literature, the following hypothesis appears warranted:

Since the CV-CAT (Miller, 1989) matches the equipment and feedback demands of the CAT-208 (Reitan & Wolfson, 1985), the research hypothesis of the present study is as follows: The CV-CAT will more effectively differentiate brain-injured non-brain-injured individuals than either the CAT-208 or the BCT. This would be reflected in a significantly higher mean total error score, and subtest error scores, for brain-injured than for non-brain-injured individuals on the CV-CAT.

In addition, exploratory analyses will examine the relationship between Category Test performance and the WAIS-R Full Scale Intelligence Quotient (FSIQ), Verbal Scale Intelligence Quotient (VSIQ), Performance Scale Intelligence Quotient (PSIQ), scaled and age-corrected subtest scores (Wechsler, 1981), and factor scores (Kaufman, 1990).

CHAPTER II

METHOD

Subjects

Fifty-seven ($N = 57$) healthy adults were tested for inclusion in the control group for this study. Of these, eight ($N = 8$) were eliminated for (a) Beck Depression Inventory (BDI, Beck & Steer, 1987) scores greater than 18 ($BDI > 18$, $N = 2$), (b) a history of learning disability ($N = 2$), (c) a history of head-injury ($N = 3$), and (d) a history of loss of consciousness without concurrent head-injury ($N = 1$).

Forty-nine ($N = 49$) adults (Females, $N = 27$, 55.1%; Males, $N = 22$, 44.9%) were included in the final sample as control subjects. Average age was 21 ($M = 21.18$) with a range of 23 years. Most subjects were right-handed ($N = 46$, 91.8%), the remainder were left-handed ($N = 3$, 6.1%) or ambidextrous ($N = 1$, 2.0%). Education range was 5 years with an average education level of 13.61 ($M = 13.61$). Most control subjects reported English as their primary language ($N = 46$, 93.9%) with the remainder of the sample as bilingual ($N = 3$, 6.1%). The majority of the control group was single ($N = 47$, 95.9%) with one subject divorced ($N = 1$,

2.0%). A summary of demographic information for the control group appears in Table 1, Appendix B.

Fifty-two ($N = 52$) brain-injured adults were tested for inclusion in this study. Of these, seven ($N = 7$) were eliminated for exceeding 50 years in age. No cut-off score on the BDI was used as an exclusion criteria for brain-injured individuals.

Forty-five ($N = 45$) brain-injured adults (Females, $N = 1$, 2.2%; Males, $N = 44$, 97.8%) were included in the final sample. All brain-injured adults lived in community based residential facilities in North Texas. Of these, 29% ($N = 13$) participated in outpatient rehabilitation, while the remainder (71%, $N = 32$) did not. Most brain-injured adults were several years post-injury ($M = 6.46$) with a range of 23 years post-injury. Trauma including motor vehicle and motorcycle accidents and other head trauma was the etiological factor responsible for most brain-injuries ($N = 39$, 86.7%). Anoxia ($N = 3$, 6.7%), cerebrovascular accident ($N = 2$, 4.4%), and infectious disease ($N = 1$, 2.2%) comprise the additional etiological factors. Average age was 33.87 ($M = 33.87$) with a range of 31 years. The majority of brain-injured subjects were right-handed ($N = 42$, 93.3%) with the remainder as left-handed ($N = 3$, 6.7%). Education range was 14 years with an average education level of 12.73 years ($M = 12.73$). Most brain-injured subjects reported English as their primary language ($N = 43$, 95.6%) with the

remainder of brain-injured subjects as bilingual ($N = 2$, 4.4%). The majority of brain-injured subjects were single ($N = 24$, 53.3%), with 10 subjects married ($N = 10$, 22.2%) 10 divorced ($N = 10$, 22.2%) and one widowed ($N = 1$, 2.2%). A summary of demographic information for the brain-injured group appears in Table 3, Appendix B.

Instrumentation

In addition to the three versions of the Category Test (DeFilippis & McCampbell, 1979; Miller, 1989; Reitan & Wolfson, 1985) the Wechsler Adult Intelligence Scale-Revised as a Neuropsychological Instrument (Kaplan et al., 1991) served as the second assessment instrument. The WAIS-R NI provided the measures of verbal and nonverbal intelligence, and memory functions. No reliability or validity information is available for the WAIS-R NI. It is essentially similar to the WAIS-R, in that, it provides clinicians with standardized IQs, subtests, and the possibility to derive factor scores. However, it also provides clinicians with an opportunity to test the limits in a standardized format with neurological impaired individuals. Average test-retest (7 week interval) correlation coefficients for the WAIS-R are: (a) FSIQ = .97, (b) VSIQ = .97, (c) PSIQ = .93, (d) Information = .89, (e) Digit Span = .83, (f) Vocabulary = .96, (g) Arithmetic = .84, (g) Comprehension = .84, (h) Similarities = .84, (i) Picture Completion = .81, (j)

Picture Arrangement = .74, (k) Block Design = .87, (l) Object Assembly = .68, and (m) Digit Symbol = .82 (Wechsler, 1981). Since no deviation from the parameters of a standard administration of the WAIS-R occurred in this study, other than testing the limits (WAIS-R NI, Kaplan et al., 1991), reliability indices should remain equivalent.

Wechsler (1981) did not report validity information on the WAIS-R; instead, since the "WAIS-R measures the same abilities as the 1955 WAIS (Wechsler, 1955) and its predecessor the 1939 Wechsler-Bellevue Intelligence Scale (Wechsler, 1939), and overlaps considerably in test content with these earlier forms of the Wechsler adult scale, studies with the WAIS and Wechsler-Bellevue can be considered relevant" to discussions of validity (Wechsler, 1981, p. 49). For validity, Wechsler (1958) argued that functions assessed by the 11 subtests of the WAIS not only fit the definition of intelligence but had proven clinical utility. For example, Guertin, Ladd, Frank, Rabin, and Hiester (1966) noted that WAIS FSIQs were salient predictors of institutional release rate and work adjustment with mentally retarded individuals. In addition, the WAIS has repeatedly correlated with other measures of intelligence. For example, reported correlation coefficients range from .43 to .93, with a median of .72, for the WAIS FSIQ and Raven's (Raven, 1965) Progressive Matrices (Anderson, Kern, & Cook, 1967, 1968; Granick, 1971; Hall, 1957; Jurjevich,

1967; McLeod & Rubin, 1962; Pringle & Haanstad, 1971; Orme, 1968; Shaw, 1967; Sydiaha, 1967). Correlations between the WAIS FSIQ and the Stanford-Binet L-M (Terman & Merrill, 1960) range from .45 to .90 with a median of .78 (Cochran & Pedrini, 1969; Fisher, Kilman, & Shotwell, 1961; Kangas & Bradway, 1971; Kennedy, Willcutt, & Smith, 1963; Kroske, Fretwell, & Cupp, 1965; McKerracher & Scott, 1966). Finally, correlations between the WAIS FSIQ and the Peabody Picture Vocabulary Test (Dunn, 1965) range from .61 to .91 with a median of .74 (Anastasi, 1988; Zimmerman, Woo-Sam, & Glasser, 1973).

Recent studies suggest, however, that mean IQs are lower on the WAIS-R when compared to the WAIS. Wechsler (1981), in a sample of 72 individuals, reported the following correlation coefficients for the WAIS and WAIS-R: (a) .91 for the VSIQ, (b) .79 for the PSIQ, and (c) .88 for the FSIQ. Other studies comparing the WAIS and WAIS-R have also reported lower IQs for the WAIS-R (Edwards & Klein, 1984; Kelly, Montgomery, Fellman, & Webb, 1984; Mitchell, Grandy, & Lupo, 1986; Rogers & Osborne, 1984; Ryan, Rosenberg, & Heilbronner, 1984; Ryan, Rosenberg, & Prifitera, 1983; Simon & Clopton, 1984). Sattler (1990) suggested "a different relationship may exist between the WAIS-R and the WAIS at different points on the intelligence distribution. Overall, WAIS-R and WAIS IQs are not interchangeable" (p. 223).

Despite the differences between the WAIS-R and WAIS, the WAIS-R correlates highly with other measures of intelligence. Thorndike, Hagen, and Sattler (1986) reported correlations of .90 for the WAIS-R VSIQ, .85 for the WAIS-R PSIQ, and .91 for the WAIS-R FSIQ with the Stanford-Binet Intelligence Scale: Fourth Edition Composite Score. In a sample of 21 mentally retarded individuals, correlations between the Stanford-Binet Intelligence Scale: Fourth Edition Composite score and the WAIS-R were: (a) .74 for the WAIS-R VSIQ, (b) .68 for the WAIS-R PSIQ, and (c) .79 for the WAIS-FSIQ (Thorndike, Hagen, & Sattler, 1986).

In addition to the Category Test and WAIS-R NI, the BDI (Beck & Steer, 1987) served as a screening instrument for the presence or absence of depression in normal controls. The BDI is a 21-item test "designed to assess the severity of depression in adolescents and adults" (Beck & Steer, 1987, p. 1). It assessed 21 symptoms and attitudes, these were: (a) mood, (b) pessimism, (c) sense of failure, (d) self-dissatisfaction, (e) guilt, (f) punishment, (g) self-dislike, (h) self-accusations, (i) suicidal ideas, (j) crying, (k) irritability, (l) social withdrawal, (m) indecisiveness, (n) body image change, (o) work difficulty, (p) insomnia, (q) fatigability, (r) loss of appetite, (s) weight loss, (t) somatic preoccupation, and (u) loss of libido.

Coefficient alphas are .86 for psychiatric patients and .81 for non-psychiatric controls. Test-retest reliability coefficients range from .48 to .86 for psychiatric patients and .60 to .90 for non-psychiatric controls. In terms of validity, the BDI has successfully differentiated individuals diagnosed as Dysthymic from individuals diagnosed with Major Depressive Disorder. In addition, the BDI has successfully differentiated individuals diagnosed with Major Depressive Disorder from those diagnosed with Generalized Anxiety Disorder (Beck & Steer, 1987). Cut-off scores on the BDI are 0-9 for asymptomatic individuals, 10-18 for mild to moderate depression, 19-29 for moderate to severe depression, and 30-63 for extremely severe depression.

Procedure

Subjects participated in a single session, approximately 4 hours in length. The experimenter provided a brief explanation of the study and informed the subjects of their right to participate or not participate. After this explanation, the experimenter distributed a packet containing an informed consent form (Appendix A). After the subject read and signed the informed consent form, random assignment to one of three conditions followed. In Condition 1, the tests and order of administration were: BDI, WAIS-R NI, and the CV-CAT. In Condition 2, the tests and order of administration were: BDI, WAIS-R NI, and BCT.

In Condition 3, the tests and order of administration were:
BDI, WAIS-R NI, and the CAT-208 as recommended by Reitan and
Wolfson (1985).

CHAPTER III

RESULTS

The research hypothesis employed a 2 X 3 factorial design. Independent variables included three versions of the Category Test (CV-CAT, CAT-208, BCT) and group membership. The dependent variable was the total error score on the Category Test and error scores for each of the seven subtests. The research hypothesis stated that the CV-CAT would be more effective in differentiating brain-injured from non-brain-injured individuals than either the CAT-208 or the BCT. This would result in significantly higher total error scores on the CV-CAT for brain-injured as opposed to non-brain-injured individuals. A summary of the descriptive test results for the control group appears in Table 3, Appendix B; while, a summary of the descriptive test results for the brain-injured group appears in Table 4, Appendix B. A representation of mean performance (brain-injured and non-brain-injured groups) for total score on all three versions of the Category Test appears in Figure 1, Appendix C.

The total error score did not correctly identify 8 of 45 (18%) brain-injured individuals and incorrectly identified 5 of 49 (10%) of normal controls. Brain-injured subjects (Table 4, Appendix B), regardless of Category Test version, had higher total error scores than did non-brain-

injured subjects (Table 3, Appendix B). Analysis of variance (ANOVA) indicated no significant differences between versions of the Category Test or an interaction between Category Test version and group membership for total error scores (Table 5, Appendix B). However, for total error scores, a significant main effect did occur for group membership ($F = 90.81$, $df = 1$, $p < .000$).

Analysis of individual subtest error scores on the Category Test followed the test of total error score. The mean scores on each subtest for group membership (brain-injured v. non-brain-injured) appears in Table 6, Appendix B. Multivariate analysis of variance (MANOVA) was performed between versions of the Category Test and error scores for each subtest. No significant main effect was found between versions of the Category Test for Subtest 1, Subtest 2, Subtest 4, Subtest 5, or Subtest 7. No interactions occurred between Category Test version and group membership on any of the seven subtests (Table 5, Appendix B). A significant main effect occurred for Category Test Version on Subtest 3 ($F = 4.35$, $df = 2$, $p < .016$) and Subtest 6 ($F = 3.59$, $df = 2$, $p < .032$). Post hoc analysis using Student-Newman-Keuls indicated significant differences ($p < .05$) between the CAT-208, the CV-CAT, and the BCT on Subtest 3. Individuals in the BCT group ($M = 19.84$) had significantly higher error scores on Subtest 3 than did individuals in either the CAT-208 group ($M = 13.92$) or the CV-CAT group ($M = 13.55$). Post

hoc analysis also indicated significant differences ($p < .05$) between the CV-CAT and the BCT on Subtest 6.

Individuals in the CV-CAT group ($M = 11.28$) had significantly higher error scores on Subtest 6 than did individuals in the BCT group ($M = 7.84$). No significant difference ($p > .05$) occurred between the CV-CAT and the CAT-208 on Subtest 6.

Brain-injured subjects had higher error scores on Subtest 1, Subtest 3, Subtest 4, Subtest 5, Subtest 6, and Subtest 7 when compared to normal controls (Table 6, Appendix B). Thus, group membership produced a significant main effect on all Category Test subtests (Table 5, Appendix B) except Subtest 2.

Exploratory Analyses

Several exploratory analyses examined the relationship between the WAIS-R intelligence quotients, factor scores, and supplemental measures included in the WAIS-R NI. Exploratory analyses employed a 2 X 3 factorial design and point-biserial correlations. The independent variable was group membership. The dependent variables were WAIS-R intelligence quotients, factor scores, and the supplemental measures included in the WAIS-R NI.

The first exploratory analysis examined the relationship between neuropsychological impairment and the WAIS-R VSIQ, PSIQ, FSIQ, and the Verbal Comprehension, Perceptual Organization, and Freedom from Distractibility

factor scores. The rationale for use of these scores was based on the recommendation by Sattler (1990) for use of these measures (VSIQ, PSIQ, FSIQ, Verbal Comprehension, Perceptual Organization, Freedom from Distractibility) in his successive level approach to interpretation of Wechsler scales. Brain-injured subjects (Table 4, Appendix B) had lower scores on these measures when compared to normal controls (Table 3, Appendix B). MANOVA indicated a significant main effect for group membership on the WAIS-R VSIQ, PSIQ, FSIQ, and the Verbal Comprehension, Perceptual Organization, and Freedom from Distractibility Factor scores ($F = 23.47$, $df = 1$, $p < .000$). All Univariate F-tests were significant (Table 7, Appendix B). Point-biserial correlations were calculated to determine relationship directionality between neuropsychological impairment and the WAIS-R VSIQ, PSIQ, FSIQ, and the Verbal Comprehension, Perceptual Organization, and Freedom from Distractibility factor scores. Point-biserial correlations indicated a significant negative relationship ($p < .01$) between neuropsychological impairment and the WAIS-R VSIQ, PSIQ, FSIQ, and the Verbal Comprehension, Perceptual Organization, and Freedom from Distractibility Factor scores (Table 8, Appendix B).

The second exploratory analysis examined the relationship between neuropsychological impairment and the remaining WAIS-R factor scores (Verbal Conceptualization,

Spatial, Sequential, Acquired Knowledge, Fluid Intelligence, Crystallized Intelligence, and Retention). Brain-injured subjects (Table 4, Appendix B) had lower scores on these measures when compared to normal controls (Table 3, Appendix B). MANOVA indicated a significant main effect for group membership on the WAIS-R Verbal Conceptualization, Spatial, Sequential, Acquired Knowledge, Fluid Intelligence, Crystallized Intelligence, and Retention Factor scores ($F = 35.70$, $df = 1$, $p < .000$). All Univariate F-tests were significant (Table 7, Appendix B). Point-biserial correlations were calculated to determine relationship directionality between neuropsychological impairment and the WAIS-R Verbal Conceptualization, Spatial, Sequential, Acquired Knowledge, Fluid Intelligence, Crystallized Intelligence, and Retention Factor scores. Point-biserial correlations indicated a significant negative relationship ($p < .01$) between neuropsychological impairment and the WAIS-R Verbal Conceptualization, Spatial, Sequential, Acquired Knowledge, Fluid Intelligence, Crystallized Intelligence, and Retention Factor scores (Table 8, Appendix B).

The third exploratory analysis examined the relationship between Category Test total error score and the WAIS-R VSIQ, Freedom from Distractibility Factor score, Spatial Factor score, Block Design Scaled score, Object Assembly Scaled score, and Digit Symbol Scaled score. A

score of 51 errors, the cut-off recommended by Reitan and Wolfson (1985) for neuropsychological impairment, on the Category Test was used to determine group membership. Mean performance indicated that individuals with less than 51 errors on the Category Test had significantly higher scores on these measures than individuals with greater than 51 errors on the Category Test (Table 9, Appendix B). A significant main effect occurred for group membership (based on Category Test total error score) on the WAIS-R VSIQ, Freedom from Distractibility Factor score, Spatial Factor score, Block Design Scaled score, Object Assembly Scaled score, and Digit Symbol Scaled score ($F = 16.44$, $df = 1$, $p < .000$). All Univariate F-tests were significant (Table 10, Appendix B). Point-biserial correlations were calculated to determine relationship directionality between group membership based on Category Test total error score and the WAIS-R VSIQ, Freedom from Distractibility Factor score, Spatial Factor score, Block Design Scaled score, Object Assembly Scaled score, and Digit Symbol Scaled score. Point-biserial correlations indicated a significant negative relationship ($p < .01$) between errors on the Category Test and the WAIS-R VSIQ, Freedom from Distractibility Factor score, Spatial Factor score, Block Design Scaled score, Object Assembly Scaled score, and Digit Symbol Scaled score (Table 11, Appendix B). A summary of Pearson product-moment correlation coefficients for the control group, brain-

injured group, and total sample and the WAIS-R VSIQ, Freedom from Distractibility Factor score, Spatial Factor score, Block Design Scaled score, Object Assembly Scaled score, and Digit Symbol Scaled score appears in Table 12, Appendix B. The results of the Pearson product-moment correlation coefficients were consistent with those obtained in the MANOVA (Table 10, Appendix B).

The final exploratory analysis examined the relationship between error score on Subtest 7 of the Category Test and the WAIS-R Sequential Factor, and WAIS-R NI supplemental measures (Digit Symbol A raw score, Digit Symbol A correct symbols, Digit Symbol A incorrect symbols, Free Recall Digit Symbol raw score, and Free Recall Digit Symbol incorrect symbols). Pearson product-moment correlation coefficients were calculated to determine if a relationship existed between these measures. A summary of the Pearson product-moment correlations coefficients for the control group, brain-injured group, and total sample for the WAIS-R and WAIS-R NI measures that assess short-term memory appears in Table 13, Appendix B.

Following this, a cut-off score of greater than 5 errors on Subtest 7 of the Category Test determined group membership (Errors greater than 25%). This was equivalent to the 51 errors (25%) recommended by Reitan and Wolfson (1985) for determination of neuropsychological impairment on the Category Test total error score. Mean performance

indicated that individuals with 5 errors or less on Subtest 7 had significantly higher scores on these measures, except Free Recall Digit Symbol incorrect symbols, than individuals with greater than 5 errors on the Category Test (Table 14, Appendix B). A significant main effect occurred for group membership (based on Subtest 7 of the Category Test) on the WAIS-R Sequential Factor score and supplemental measures of the WAIS-R NI (Digit Symbol A raw score, Digit Symbol A correct symbols, Digit Symbol A incorrect symbols, Free Recall Digit Symbol raw score) ($F = 10.22$, $df = 1$, $p < .000$). All Univariate F-tests were significant except Free Recall Digit Symbol incorrect symbols (Table 15, Appendix B). Point-biserial correlations were calculated to determine relationship directionality between group membership based on Category Test Subtest 7 error score and the supplemental measures included in the WAIS-R NI. Point-biserial correlation indicated a significant negative relationship ($p < .01$) between errors on Subtest 7 of the Category Test and the Sequential Factor of the WAIS-R, Digit Symbol A raw score, Digit symbol A correct symbols, and Free Recall Digit Symbol raw scores; while, point-biserial correlation indicated a significant positive relationship ($p < .05$) between errors on Subtest 7 of the Category Test and Digit Symbol A incorrect symbols (Table 16, Appendix B). These results were consistent with those obtained in the calculation of Pearson product-moment correlation

coefficients (Table 13, Appendix B), with the exception of Free Recall Digit Symbol incorrect symbols. Pearson product-moment correlation indicated a significant negative relationship ($p < .01$) on Free Recall Digit Symbol incorrect symbols for the total sample. However, scores on this measure were not significant at the multivariate level (Table 15, Appendix B).

CHAPTER IV

DISCUSSION

This study investigated whether or not there was a difference among three full forms of the Category Test. The primary goal of this study was to show criterion-related validity for the CAT-208 (Reitan & Wolfson, 1985), the BCT (DeFilippis & McCampbell, 1979), and the CV-CAT (Miller, 1989). The criterion, in this study, was the presence of neuropsychological impairment. A secondary goal of this study was to examine the relationship between the supplemental measures in the WAIS-R NI (Kaplan et al., 1991), the Category Test, and how the presence of a brain-injury affected this relationship.

The results from this study did not support the research hypothesis. Results indicated no significant difference among the three versions of the Category Test (Table 5, Appendix B). Despite the contention of Reitan and Wolfson (1985) that altered forms of the CAT-208 lack adequate reliability and validity, the results from this study suggest that the Category Test is robust to alterations in instrumentation. This finding is consistent with previous research that suggests that alterations in instrumentation do not affect the Category Test (Beaumont, 1975; DeFilippis & McCampbell, 1979; DeFilippis et al.,

1979; Kupke, 1983; MacInnes et al., 1981; McCampbell & DeFilippis, 1979; Miller, 1989).

The results do indicate, however, that regardless of Category Test version the total error score on the Category Test effectively differentiates brain-injured from non-brain-injured individuals. This is consistent with previous research that indicates the total error score on the Category Test effectively discriminates brain-injured from non-brain-injured individuals (Boyle, 1988; Charter et al., 1987; Corrigan et al., 1987; Davidoff et al., 1985; Everett, 1984; Goldstein, 1990; Horton & Siegel, 1990; Matarazzo et al., 1974; Matarazzo et al., 1976; Moses, 1985; Pendleton & Heaton, 1982; Roth et al., 1989; Sarazin & Spreen, 1986). Although, the three versions did not differ in terms of total score, the trend (Figure 1, Appendix C) suggests that the BCT and CV-CAT are more sensitive to the effects of brain-injury. Therefore these two versions should, at least, be considered equivalent to the CAT-208.

The results did indicate significant differences between the CAT-208, the CV-CAT, and the BCT on Subtest 3 and Subtest 6. Individuals in the BCT group had significantly higher error scores on Subtest 3 than did individuals in the CAT-208 or CV-CAT group. Individuals in the CV-CAT group had significantly higher error scores on Subtest 6 than did individuals in the BCT group. Despite the contention of Reitan and Wolfson (1985) that altered

forms of the CAT-208 are inadequate substitutes for the standard administration, results from this study suggest that the BCT is more sensitive to neuropsychological impairment on Subtest 3 than is either the CAT-208 or the CV-CAT; while, the CV-CAT is more sensitive to neuropsychological impairment on Subtest 6 than the BCT. Even though no significant differences occurred between the CV-CAT and CAT-208 on Subtest 6, an examination of means indicates that individuals in the CV-CAT group had higher error scores on Subtest 6 than did individuals in the CAT-208 group (Table 6, Appendix B). It is possible, with a larger sample, that this difference would have reached significance.

With the exception of Subtest 2, individual subtests of the Category test effectively distinguished brain-injured from non-brain-injured individuals. The discriminating power of each subtest suggests that development of a short-form of the Category Test may have applied value (Boyle 1975; Calsyn et al., 1980; Gregory et al., 1979; Kilpatrick, 1970; Labreche, 1983; Russell & Levy, 1987; Russell & Barron, 1989; Sherrill, 1985; Summers & Boll, 1987; Taylor et al., 1990). Considering the simplicity of Subtest 2, and its lack of ability to differentiate brain-injured from non-brain-injured individuals, abbreviated versions may consider either dropping Subtest 2 in its entirety or substantially reducing the number of items retained.

The first two exploratory analyses examined the relationship between neuropsychological impairment and the WAIS-R intelligence quotients (VSIQ, PSIQ, FSIQ) and factor scores (Verbal Comprehension, Perceptual Organization, Freedom from Distractibility, Verbal Conceptualization, Spatial, Sequential, Acquired Knowledge, Fluid Intelligence, Crystallized Intelligence, Retention). Results indicated that the WAIS-R intelligence quotients and factor scores effectively differentiated brain-injured from non-brain-injured individuals (Tables 3-8, Appendix B). This is consistent with previous research that suggests a reduction in IQ scores following a head-injury in both adults (Bigler, Steinman, & Newton, 1981; Brooks, 1983; Jennett, 1986; Levin, Benton, & Grossman, 1982) and children (Chadwick, Rutter, Brown, Schaffner, & Traub, 1981; Chadwick, Rutter, Schaffner, & Shrout, 1981; Levin & Eisenberg, 1979). Since factor scores employ age-corrected subtest scores (Kaufman, 1990) based on the same raw scores as scaled scores, it is reasonable to assume that a similar reduction in factor scores would accompany head-injuries.

As indicated in the introduction, several neuropsychological abilities appear to encompass successful performance on the Category Test, these are: (a) abstraction, (b) visuospatial skills, (c) attention and concentration, (d) short-term memory, and (e) psychomotor speed. In addition, some research implies that the Category

Test is a nonverbal task and does not require verbal abilities. The final two exploratory analyses attempted to verify if successful performance on the Category Test comprised these abilities.

Results from the third exploratory analysis indicated a significant relationship between the Category Test total error score and the WAIS-R factors and scaled scores that assessed short-term memory (Sequential Factor, Digit Symbol Scaled score), attention and concentration (Freedom from Distractibility Factor), abstraction (Block Design and Object Assembly Scaled scores), psychomotor speed (Digit Symbol), and visuospatial skills (Spatial Factor, Block Design and Object Assembly Scaled scores). The results indicated that as errors increased on the Category Test performance on the WAIS-R measures declined. It appears that successful performance on the Category Test requires competency in short-term memory, attention and concentration, abstraction, psychomotor speed, and visuospatial skills. This finding is consistent with the hypothesized neuropsychological functions tapped by the Category Test (Boyle, 1988; Golden et al., 1981; Halstead, 1947; Klonoff, 1971; Lansdell & Donnelly, 1977; Nussbaum & Bigler, 1989; Rattan et al., 1986; Reitan & Wolfson, 1985; Rothke, 1986; Swiercinsky, 1979).

Of interest was the significant correlation ($r = -.66$, $p < .01$) between the VSIQ and the Category Test total error

score, a finding in contrast to suggestions that the Category Test does not require verbal abilities (Corrigan & Hinkeldey, 1988; Corrigan et al., 1987; Dodrill & Troupin, 1975; Halstead, 1947). It is consistent, however, with previous research that questions the nonverbal properties of the Category Test (Lin & Rennick, 1974; Shore et al., 1971; Seidenberg, Giordani, Berent, & Boll, 1983; Yeudall et al., 1987). Several explanations may account for this discrepancy: First, both the BCT and CV-CAT utilized verbal feedback ("correct," "incorrect") in administration, as opposed to the simple auditory feedback ("doorbell," "buzzer") in the CAT-208. The use of verbal feedback in the BCT and CV-CAT may have affected the nonverbal properties of the Category Test. Second, it is possible that subjects used verbal techniques to encode visual representations. For example, in Subtest 2, a subject may have encoded "4 As" as opposed to "4 letters" and then used the verbal cues to recall the correct answer to the visual representations.

Subtest 7 of the Category Test as a test of memory requires subjects to recall answers to previously viewed patterns. Instructions to the subject encourage the use of memory: "In this last subtest there is no one principle or idea that runs throughout the group because it is made up of items that you have seen before. Try to remember what the right answer was the last time you saw the pattern and give that same answer again" (Reitan & Wolfson, 1985, pp. 43-44).

The final exploratory analysis examined the relationship between Subtest 7 (Memory subtest) error score and the supplemental measures included in the WAIS-R NI designed to assess short-term memory (Digit Symbol A raw score, Digit Symbol A correct symbols, Digit Symbol A incorrect symbols, Free Recall Digit Symbol raw score, and Free Recall Digit Symbol incorrect symbols). Results indicated a significant relationship, except for Free Recall Digit Symbol incorrect symbols, between Subtest 7 error score and the WAIS-R NI supplemental measures that assessed short-term memory. The results indicated that as errors increased on Subtest 7 performance on Digit Symbol A raw score, Digit Symbol A correct symbols, and Free Recall Digit Symbol raw score declined. In addition, the results indicated that as errors increased on Subtest 7, Digit Symbol A incorrect symbols increased. It appears that successful performance on Subtest 7 of the Category Test requires competency in short-term memory. This is consistent with Nussbaum and Bigler (1989) who noted that successful performance on the Category Test required sufficient capacity for short-term memory. Free Recall Digit Symbol incorrect symbols did not differentiate individuals based on error score on Subtest 7. Number of perseverations, not scored in Free Recall Digit Symbol, may provide substantial information as to the cognitive processes of brain-injured individuals. Normal controls typically quit after 7-9 distinct symbols on Free

Recall Digit Symbol; while, in contrast, brain-injured subjects often reproduced the same symbol several times. Failure occurred on a symbol only if the reproduction was incorrect and perseverations on the same symbol did not result in a higher error score. Thus, a score for perseverations on Free Recall Digit Symbols may provide not only beneficial information unavailable in the current scoring system but may differentiate brain-injured from non-brain-injured individuals more effectively than incorrect symbols.

Results from this study are consistent with previous research in terms of the difference between altered forms of the Category Test (Beaumont, 1975; DeFilippis & McCampbell, 1979; DeFilippis et al., 1979; Kupke, 1983; MacInnes et al., 1981; McCampbell & DeFilippis, 1979; Miller, 1989), the relationship between neuropsychological impairment and Category Test performance (Boyle, 1988; Charter et al., 1987; Corrigan et al., 1987; Davidoff et al., 1985; Everett, 1984; Goldstein, 1990; Horton & Siegel, 1990; Matarazzo et al., 1974; Matarazzo et al., 1976; Moses, 1985; Pendleton & Heaton, 1982; Roth et al., 1989; Sarazin & Spreen, 1986), the relationship between neuropsychological impairment and the WAIS-R intelligence quotients and factor scores (Bigler et al., 1981; Brooks, 1983; Chadwick et al., 1981; Chadwick et al., 1981b; Jennett, 1986; Levin et al., 1982; Levin & Eisenberg, 1979), and the suspected neuropsychological

functions tapped by the Category Test (Boyle, 1988; Golden et al., 1981; Halstead, 1947; Klonoff, 1971; Lansdell & Donnelly, 1977; Nussbaum & Bigler, 1989; Rattan et al., 1986; Reitan & Wolfson, 1985; Rothke, 1986; Swiercinsky, 1979). Despite these consistencies, however, several considerations should be noted regarding this study.

First, the use of a cross-sectional design reduces generalizability due to the confounding of age and cohort. Intraindividual change is estimated via age-group differences and may not represent an accurate estimate unless cohort effects are negligible (Baltes, Reese, & Nesselroade, 1988). The age range of 23 years in normal controls and 31 years in the brain-injured group raises the possibility that cohort effects may impact the generalizability of this study. In addition, this research study did not employ a repeated measures design. Since a significant practice effect occurs with repeated administrations of the Category Test (DeFilippis et al., 1979; McCampbell & DeFilippis, 1979) it was impractical to consider a repeated measures design. Longitudinal administrations at 6 month intervals, to control for the practice effect, may permit the use of a repeated measures design with the Category Test.

Another variable that might affect the results from this study is past rehabilitation experience. Very little information was available about individual rehabilitation efforts. Chart information was limited and, when

questioned, some patients could not recall specific rehabilitation details. Contact with family members to confirm rehabilitation information was not possible, since patients were guaranteed confidentiality. Only a small portion of patients (29%, $N = 13/45$) reported active involvement in rehabilitation. Prigatano (1990) noted that "recovery of various aspects of higher cerebral functions may indeed be differentially determined and resistant or responsive to different rehabilitation experiences" (p. 278). It is possible that involvement, or lack of involvement, in rehabilitation affected individual neuropsychological performance.

A larger sample size would, of course, have been desirable. While it is not uncommon in research involving brain-injuries to use small sample sizes (Boyle, 1988; Bornstein, 1986; Brandon & Chavez, 1985; Childs, Mercer, Childs, 1993; Corrigan et al., 1987; Cullum et al., 1984; Dodrill & Troupin, 1975; Glyshaw, 1990; Lansdell & Donnelly, 1977; Rattan et al., 1986; Rothke, 1986; Ryan et al., 1983; Seidenberg et al., 1983; Shute & Huertas, 1990; Shore et al., 1971; Tupper, 1990) this undoubtedly limits generalizations of the results to larger patient groupings.

Another consideration regarding sample size is the number of exploratory analyses. With multiple comparisons, and a small sample, the probability of Type I error increases. Adjustments are necessary, such as protected t tests (Cohen, 1977; Cohen, 1982; Cohen & Cohen, 1975) or

Bonferonni (Dunn, 1961), with multiple comparisons to avoid rejecting the null too readily. However, Rothman (1986, 1990) noted that no adjustments for "multiple comparisons should be made even if a large number of comparisons are reported at one time, provided that it is clear how many comparisons have been made and that all 'negative' (that is 'nonsignificant') results have been reported along with the 'positive' or 'significant' results" (1986, p. 149). In addition, Winer (1971) noted that the "evidence provided by a single experiment with respect to the truth or falsity of a statistical hypothesis is seldom complete enough to arrive at a decision which is free of all error" (p. 14). Since the exploratory analyses serve only as a guideposts for future research, the probability of inflating Type I error was not a major concern. However, caution is encouraged in interpreting the exploratory analyses because, it is possible, that multiple comparisons inflated the probability of Type I error.

Future research should address several variations of the current study. It is now possible to expand this research to include four (and possible five) versions of the Category Test. These would include the CAT-208, BCT, CV-CAT (Monochrome), CV-CAT (Color, Miller, 1993), and the IBM Computerized Version of the Category Test (IBM CV-CAT, DeFilippis, 1993), the later two (CV-CAT [Color], IBM CV-CAT) were not available at the beginning of this study. Research should first show criterion-related validity for

each of these five versions and then consider a repeated measures design with all five measures of the Category Test. The possibility of changing the feedback mechanisms of the CV-CAT (Monochrome and Color) and the IBM CV-CAT to match those of the CAT-208 ("doorbell," "buzzer") should be considered. This would enable researchers to examine how different forms of feedback (simple auditory, verbal, visual) affect performance on the Category Test. Also, factor analytic studies, using larger samples, may enable researchers to determine the feasibility of shortening computerized versions of the Category Test without sacrificing clinical utility.

Future research also should continue to examine the supplemental measures included in the WAIS-R NI. In particular, the relationship between a standard administration of the WAIS-R Block Design and the administration method for Block Design (not used in this study) as recommended by Kaplan et al. (1991) should be investigated. The administration recommended by Kaplan et al. (1991) does not allow the generation of a standard scaled score that, in turn, eliminates the possibility of obtaining the Perceptual Organization, Spatial, and Fluid Intelligence Factor scores. It would be valuable to determine if clinicians could use the administration method recommended by Kaplan et al. (1991) and still obtain a scaled score for Block Design. Finally, a comparison between the supplemental measures included in the WAIS-R NI

and their relationship to other neuropsychological measures may provide information regarding the possibility of overlap between these tasks. For example, comparisons of Spatial Span (WAIS-R NI) and Visual Memory Span (WMS-R) may demonstrate that both tasks assess short-term memory and provide essentially the same clinical information. If each measure taps the same basic psychological function then it is unnecessary to use both measures in neuropsychological assessment.

The results from this study have immediate applicability to clinicians who work with brain-injured individuals. First, this study demonstrates that altered forms of the Category Test (Beaumont, 1975; DeFilippis & McCampbell, 1979; DeFilippis et al., 1979; Kupke, 1983; MacInnes et al., 1981; McCampbell & DeFilippis, 1979; Miller, 1989) are adequate substitutes for the cumbersome CAT-208. With the increased availability of lap-top computers the CV-CAT will demand less space than either the CAT-208 or the BCT; yet, it will yield essentially the same results as the CAT-208 or BCT.

Finally, the CV-CAT provides clinicians with an alternate form of the Category Test. Few clinical tests have alternate versions and the computerized versions may allow clinicians to vary test versions without losing valuable clinical information. One problem encountered in neurorehabilitation is the practice effect that occurs with the use of serial neuropsychological testing. The practice

effect restricts the monitoring of treatment efficacy because it is difficult to determine if gains are the result of rehabilitation interventions or simply the result of practice effects (Coutts, Lichstein, Bermudez, Daigle, Mann, Charbonnel, Michaud, & Williams, 1987; McCaffrey, Ortega, Orsillo, Nelles, & Haase, 1992; Mitrushina, Satz, Gordon, & Perez, 1991; Rawlings & Crewe, 1992). The creation of alternate forms of the Category Test (CAT-208, BCT, CV-CAT, and IBM CV-CAT) would allow serial neuropsychological testing, possibly without practice effects due to changes in instrumentation, in rehabilitation to index patient improvement.

APPENDIX A
INFORMED CONSENT

Informed Consent Form

Investigators: E. H. Harrell, Ph. D., Walt Mercer,
M.R.E.

Purpose of the Study: The purpose of this study is to examine the performance of brain-damaged versus non-brain-damaged individuals on three forms of a neuropsychological test.

Procedures: The participant will attend one session of neuropsychological testing. This session will take approximately 2 hours.

Safeguards: The participant's answers will be kept completely confidential. Only first names and code numbers will be used. I am not interested in comparing individual responses, only group responses will be examined.

Participation in this study is entirely voluntary, and you may end your participation at any time you desire. To the best of our knowledge, participation will not cause any physical or psychological harm.

Benefits: Not only does participation in this study provide a new experience for the individual, it may provide an opportunity for new growth and development.

This study provides an opportunity to increase our understanding of the performance of brain-damaged individuals. Potentially this may benefit society in general and handicapped individuals in particular as we learn more about their challenges and possible ways to remediate these deficits. More effective and expedient ways to assess the deficits faced by acquired brain injured individuals may be one possible outcome of this study.

Additional Questions: Additional questions regarding your participation, or this study, may be directed to Walt Mercer or E. H. Harrell.

Informed Consent Form

This is to certify that I _____
am _____ (your name)
participating as a volunteer in a scientific study as an
authorized part of the educational and research program of
the University of North Texas.

The investigation and my part in the investigation have been
defined and fully explained to me by Walt Mercer, and I
understand his explanation. The procedures of this
investigation and their risks and discomforts have been
described in a separate statement, and are discussed in
detail.

I have been given an opportunity to ask whatever questions I
may have had, and all such questions and inquiries have been
answered to my satisfaction.

I understand that I may refuse to answer any question on the
questionnaires.

I understand that any data or answers to questions will
remain confidential, and only group data will be reported.

I FURTHER UNDERSTAND THAT I AM FREE TO WITHDRAW MY CONSENT
AND TERMINATE MY PARTICIPATION AT ANY TIME.

(date)

(signature)

APPENDIX B

TABLES

Table 1

Summary of Control Group Demographic Information

Variable	Frequency	Percent	Mean
Sex			
Males	22	44.9	
Females	27	55.1	
Language			
English	46	93.9	
English/ Spanish	1	2.0	
English/ German	1	2.0	
English/ Vietnamese	1	2.0	
Handedness			
Right	45	91.8	
Left	3	6.1	
Both	1	2.0	
Marital Status			
Single	48	98.0	
Divorced	1	2.0	
Age			21.18
Education			13.61
Alcohol Use			
Yes	27	55.1	
No	22	44.9	
Amount of Alcohol in Ounces			21.45

Table 2

Summary of Brain-Injured Group Demographic Information

Variable	Frequency	Percent	Mean
Sex			
Male	44	98.0	
Female	1	2.0	
Language			
English	43	95.6	
English/ Spanish	2	4.4	
Handedness			
Right	42	93.3	
Left	3	6.7	
Marital Status			
Single	24	53.4	
Married	10	22.2	
Divorced	10	22.2	
Widowed	1	2.2	
Age			33.87
Education			12.73
Cause of Head Injury			
MVA/MCA	22	48.9	
Stroke	2	4.4	
Trauma	17	37.8	
Anoxia	3	6.7	
Infection	1	2.2	

(Table Continues)

Table 2 -- continued

Variable	Frequency	Percent	Mean
Loss of Consciousness			
Yes	44	97.8	
No	1	2.2	
Retrograde Amnesia			
< 24 hours	23	51.1	
1-2 Days	2	4.4	
3-5 Days	2	4.4	
1 Week	1	2.2	
2 Weeks	0	0.0	
3 Weeks	0	0.0	
1 Month	2	4.4	
> 2 Months	9	20.0	
N/A	6	13.3	
Length of Loss of Consciousness			
< 24 hours	10	22.2	
1-2 Days	0	0.0	
3-5 Days	1	2.2	
1 Week	0	0.0	
2 Weeks	5	11.1	
3 Weeks	3	6.7	
1 Month	4	8.9	
> 2 Months	16	35.6	
N/A	6	13.3	

(Table Continues)

Table 2 -- continued

Variable	Frequency	Percent	Mean
Posttraumatic Amnesia			
< 24 hours	23	51.1	
1-2 Days	2	4.4	
3-5 Days	2	4.4	
1 Week	1	2.2	
2 Weeks	0	0.0	
3 Weeks	0	0.0	
1 Month	2	4.4	
> 2 Months	9	20.0	
N/A	6	13.3	
Alcohol Use			
Yes	10	22.2	
No	35	77.8	
Alcohol in Ounces Per Week			
			6.21

Table 3

Summary of Control Group Descriptive Test Results

Variable	Mean	SD	SE
VSIQ	103.76	10.01	1.60
Information	9.57	1.85	.26
Digit Span	10.29	2.35	.34
Vocabulary	10.08	1.77	.25
Arithmetic	10.59	2.26	.32
Comprehension	9.90	2.26	.32
Similarities	10.31	2.16	.31
PSIQ	107.31	11.21	1.60
Picture Completion	9.67	2.48	.35
Picture Arrangement	10.61	2.61	.37
Block Design	11.55	2.54	.36
Object Assembly	10.86	2.45	.35
Digit Symbol	12.04	2.22	.32
FSIQ	105.67	9.70	1.39

(Table Continues)

Table 3 -- continued

Variable	Mean	SD	SE
WAIS-R NI			
Digit Symbol A - Raw Score	21.71	4.02	.57
Digit Symbol A - Correct Symbols	7.57	1.54	.22
Digit Symbol A - Incorrect Symbols	.90	1.07	.15
Free Recall Digit Symbol Raw Score	8.12	1.11	.16
Free Recall Digit Symbol Incorrect Symbols	.57	.68	.10
Sentence Arrangement	16.88	3.98	.57
Spatial Span Forward - Raw Score	9.25	1.97	.28
Spatial Span Backward - Raw Score	8.71	1.37	.20

(Table Continues)

Table 3 -- continued

Variable	Mean	SD	SE
Object Assembly New Designs - Raw Score	22.31	1.82	.26
Digit Symbol Copy - Raw Score	92.98	.14	.02
Verbal Comprehension	104.92	10.34	1.48
Perceptual Organization	105.31	12.05	1.72
Freedom From Distractibility	104.71	11.09	1.58
Verbal Conceptualization	105.51	11.30	1.61
Spatial	105.31	12.05	1.72
Sequential	108.27	9.85	1.41
Acquired Knowledge	105.59	10.24	1.46
Fluid Intelligence	106.06	9.78	1.40
Crystallized Intelligence	104.92	10.34	1.48
Retention	104.65	10.11	1.44

(Table Continues)

Table 3 -- continued

Variable	Mean	SD	SE
Category Test - Total Errors	30.94	13.57	1.94
Subtest 1	.10	.31	.04
Subtest 2	.31	.51	.07
Subtest 3	8.74	8.47	1.21
Subtest 4	3.53	4.12	.59
Subtest 5	10.88	6.01	.86
Subtest 6	5.67	4.62	.66
Subtest 7	1.69	1.50	.22

Table 4

Summary of Brain-Injured Group Descriptive Test Results

Variable	Mean	SD	SE
VSIQ	84.47	12.98	1.94
Information	7.16	3.16	.47
Digit Span	7.20	2.97	.44
Vocabulary	7.11	2.63	.39
Arithmetic	7.42	3.02	.45
Comprehension	6.87	2.56	.38
Similarities	7.33	3.26	.49
PSIQ	81.42	14.31	2.13
Picture Completion	7.44	2.58	.39
Picture Arrangement	6.87	2.98	.44
Block Design	6.53	2.95	.44
Object Assembly	6.93	2.90	.43
Digit Symbol	4.76	2.43	.36
FSIQ	81.96	12.69	1.89

(Table Continues)

Table 4 -- continued

Variable	Mean	SD	SE
WAIS-R NI			
Digit Symbol A - Raw Score	6.40	6.43	.96
Digit Symbol A - Correct Symbols	2.73	2.32	.35
Digit Symbol A - Incorrect Symbols	1.96	2.46	.37
Free Recall Digit Symbol Raw Score	4.27	2.36	.35
Free Recall Digit Symbol Incorrect Symbols	1.40	1.62	.24
Sentence Arrangement	6.93	6.52	.97
Spatial Span Forward - Raw Score	5.89	2.11	.32
Spatial Span Backward - Raw Score	4.91	2.41	.36

(Table Continues)

Table 4 -- continued

Variable	Mean	SD	SE
Object Assembly New Designs - Raw Score	16.56	6.77	1.01
Digit Symbol Copy - Raw Score	55.71	24.79	3.70
Verbal Comprehension	85.02	14.25	2.12
Perceptual Organization	84.67	15.06	2.25
Freedom From Distractibility	86.16	14.67	2.19
Verbal Conceptualization	85.07	14.37	2.14
Spatial	84.67	15.06	2.25
Sequential	79.96	14.28	2.13
Acquired Knowledge	85.22	14.29	2.13
Fluid Intelligence	83.33	15.45	2.30
Crystallized Intelligence	85.02	14.25	2.12
Retention	84.44	15.01	2.24

(Table Continues)

Table 4 -- continued

Variable	Mean	SD	SE
Category Test - Total Errors	77.40	31.09	4.63
Subtest 1	.42	.81	.12
Subtest 2	.42	.69	.10
Subtest 3	22.73	10.98	1.64
Subtest 4	17.71	11.18	1.67
Subtest 5	16.60	7.44	1.11
Subtest 6	12.64	7.89	1.18
Subtest 7	6.87	3.30	.49

Table 5

Summary of MANOVA Results on the Category Test

Source	SS	DF	MS	F
Total Error Score				
Version	1203.48	2	601.74	1.08
Group Membership	50643.33	1	50643.33	90.81**
Version X Group Membership	1190.09	2	595.04	1.07
Subtest 1				
Version	.85	2	.43	1.19
Group Membership	2.45	1	2.45	6.81**
Version X Group Membership	1.04	2	.52	1.45
Subtest 2				
Version	.61	2	.31	.84
Group Membership	.32	1	.32	.88
Version X Group Membership	.60	2	.30	.82

(Table Continues)

Table 5 -- continued

Source	SS	DF	MS	F
Subtest 3				
Version	774.91	2	387.46	4.35**
Group Membership	4547.23	1	4547.23	51.03**
Version X Group Membership	114.96	2	57.48	.65
Subtest 4				
Version	173.02	2	86.51	1.25
Group Membership	4726.53	1	4726.53	68.25**
Version X Group Membership	52.53	2	26.27	.38
Subtest 5				
Version	156.22	2	78.11	1.79
Group Membership	776.12	1	776.12	17.76**
Version X Group Membership	164.55	2	82.28	1.88

(Table Continues)

Table 5 -- continued

Source	SS	DF	MS	F
Subtest 6				
Version	276.95	2	138.47	3.59*
Group Membership	1148.91	1	1148.91	29.76**
Version X Group Membership	98.36	2	49.18	1.27
Subtest 7				
Version	24.69	2	12.35	1.96
Group Membership	628.38	1	628.38	99.68**
Version X Group Membership	9.56	2	4.78	.76

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

Table 6

Summary of Subtest Means on Three Versions of the
Category Test

	CAT-208		BCT		CV-CAT	
	BI	NBI	BI	NBI	BI	NBI
Subtest						
1	0.67	0.06	0.27	0.00	0.33	0.24
2	0.28	0.38	0.40	0.19	0.60	0.35
3	19.53	8.31	26.80	12.88	21.87	5.24
4	17.60	3.31	15.20	2.88	20.33	4.35
5	14.40	12.13	16.80	8.06	18.60	12.35
6	10.00	5.81	11.87	4.06	16.07	7.06
7	5.93	1.38	6.73	1.81	7.93	1.88
Total	68.40	31.38	78.07	29.88	85.73	31.53

Note. CAT-208 = Category Test (Reitan & Wolfson, 1985); BCT = Booklet Category Test (DeFilippis & McCampbell, 1979); CV-CAT = Computerized Version of the Category Test (Miller, 1989); BI = Brain-Injured; NBI = Non-brain-injured

Table 7

Summary of Univariate F-Tests for the WAIS-R NI for the
Main Effect of Group Membership (Brain-Injured v. Non-
Brain-Injured)

Variable	Error SS	Df	Error MS	F
VSIQ	12228.26	1	132.92	65.66**
PSIQ	15035.39	1	163.43	96.16**
FSIQ	11596.69	1	126.05	104.69**
Verbal Comprehension	14066.65	1	152.90	60.73**
Perceptual Organization	16956.41	1	184.31	54.22**
Freedom From Distractibility	15369.91	1	167.06	48.36**
Verbal Conceptualization	15219.04	1	165.42	59.26**
Spatial	16956.04	1	184.31	54.22**
Sequential	13627.46	1	148.12	126.92**
Acquired Knowledge	14015.61	1	152.34	63.89**
Fluid Intelligence	15094.82	1	164.07	73.85**

(Table Continues)

Table 7 -- continued

Variable	Error SS	Df	Error MS	F
Crystallized Intelligence	14066.65	1	152.90	60.73**
Block Design Scaled Score	693.80	1	7.54	78.37**
Object Assembly Scaled Score	656.80	1	7.14	50.59**
Digit Symbol Scaled Score	496.23	1	5.39	230.82**
Digit Symbol A - Raw Score	2596.80	1	28.23	194.91**
Digit Symbol A - Correct Symbols	320.40	1	3.48	7.53**
Free Recall Digit Symbol Raw Score	304.07	1	3.31	105.52**
Free Recall Digit Symbol Incorrect Symbols	136.80	1	1.49	10.83

** p < .01

Table 8

Summary of Point-Biserial Correlations Between
Neuropsychological Impairment and WAIS-R Intelligence
Quotients and Factor Scores

	VSIQ	PSIQ	FSIQ	VC	PO	CI
HI	-.65	-.71	-.73	-.63	-.61	-.63
	FFD	SF	SQ	AK	FI	RT
HI	-.59	-.61	-.76	-.64	-.67	-.63

Note. VSIQ = Verbal Scale IQ; PSIQ = Performance Scale IQ; FSIQ = Full Scale IQ; VC = Verbal Comprehension Factor; PO = Perceptual Organization Factor; CI = Crystallized Intelligence Factor; FFD = Freedom from Distractibility Factor; SF = Spatial Factor; SQ = Sequential Factor; AK = Acquired Knowledge Factor; FI = Fluid Intelligence Factor; RT = Retention Factor

All significant at $p < .01$

Table 9

Summary of Descriptive Test Results for Group
Membership Based on Category Test Total Error Score

Variable	Mean	SD	N
VSIQ			
Group 1	103.42	10.89	52
Group 2	83.50	11.18	42
PSIQ			
Group 1	103.62	12.36	52
Group 2	81.67	15.53	42
Spatial Factor Score			
Group 1	104.89	11.81	52
Group 2	83.71	15.16	42
Freedom From Distractibility			
Group 1	105.00	12.24	52
Group 2	84.48	12.12	42

(Table Continues)

Table 9 -- continued

Variable	Mean	SD	N
Object Assembly			
Group 1	10.69	2.55	52
Group 2	6.86	2.90	42
Block Design			
Group 1	11.19	2.80	52
Group 2	6.62	3.12	42
Digit Symbol			
Group 1	11.10	3.33	52
Group 2	6.62	3.12	42

Note. Group 1 = Category Test Total Error Score < 51;
 Group 2 = Category Test Total Error Score > 51.

Table 10

Summary of Univariate F-Tests for Group MembershipBased on Category Test Total Error Score

Variable	Error SS	Df	Error MS	F
VSIQ	11733.19	1	127.53	72.31**
Freedom From Distractibility	13662.48	1	148.51	65.90**
Spatial	16535.88	1	179.74	57.93**
Block Design Scaled Score	797.98	1	8.67	56.02**
Object Assembly Scaled Score	676.22	1	7.35	46.49**
Digit Symbol Scaled Score	988.64	1	10.75	70.03**

** $p < .01$

Table 11

Summary of Point-Biserial Correlations For Group
Membership Based on Category Test Total Score

	VSIQ	FFD	SF	BD	OA	DS
Group						
Membership	-.66	-.65	-.62	-.62	-.58	-.66

Note. VSIQ = Verbal Scale IQ; FFD = Freedom from Distractibility Factor; SF = Spatial Factor; BD = Block Design Scaled Score; OA = Object Assembly Scaled Score
 DS = Digit Symbol Scaled Score
 All significant at $p < .01$

Table 12

Summary of Pearson Product-Moment Correlation
Coefficients for Control Group, Brain-Injured Group,
and Total Sample On Measures of Abstraction,
Visuospatial Skills, Attention/Concentration, Short-
Term Memory, and Psychomotor Speed

	VSIQ	FFD	SF	BDS	OAS	DS
<u>NBI</u>						
VSIQ	1.00	.72**	.39**	.35**	.24	-.20
FFD	.72**	1.00	.15	.20	-.06	.05
SF	.39**	.15	1.00	.71**	.74**	-.23
BDS	.35**	.20	.71**	1.00	.46**	-.04
OAS	.24**	.06	.74**	.46**	1.00	-.25
DS	-.20	.05	-.23	-.04	-.25	1.00
<u>BI</u>						
VSIQ	1.00	.82**	.66**	.49**	.45**	.33*
FFD	.82**	1.00	.71**	.61**	.49**	.46**
SF	.66**	.71**	1.00	.80**	.87**	.57**
BDS	.49**	.61**	.80**	1.00	.66**	.64**
OAS	.45**	.49**	.87**	.66**	1.00	.55**
DS	.33*	.46**	.57**	.64**	.55**	1.00

(Table Continues)

Table 12 -- continued

	VSIQ	FFD	SF	BDS	OAS	DS
<u>Total</u>						
VSIQ	1.00	.86**	.73**	.68**	.61**	.59**
FFD	.86**	1.00	.67**	.66**	.52**	.62**
SF	.73**	.67**	1.00	.86**	.88**	.61**
BDS	.68**	.66**	.86**	1.00	.74**	.47**
OAS	.61**	.52**	.88**	.74**	1.00	.58**
DS	.59**	.62**	.61**	.47**	.58**	1.00

Note. NBI = Non-brain-injured; BI = Brain-injured;
 Total = Total Sample; VSIQ = Verbal Scale IQ; FFD =
 Freedom from Distractibility Factor; SF = Spatial
 Factor; BDS = Block Design Scaled Score; OAS = Object
 Assembly Scaled Score; DS = Digit Symbol Scaled Score

* $p < .05$

** $p < .01$

Table 13

Summary of Pearson Product-Moment Correlation
Coefficients For Control Group, Brain-Injured Group,
and Total Sample On WAIS-R and WAIS-R NI Measures of
Short-Term Memory

	SQ	DSA	DSCR	DSINC	FRDS	FRINC
<u>NBI</u>						
SQ	1.00	.03	.02	.08	.07	.04
DSA	.03	1.00	.91**	-.61**	.69**	-.47**
DSCR	.02	.91**	1.00	-.59**	.72**	-.48**
DSINC	.08	-.61**	-.59**	1.00	-.66**	.57**
FRDS	.07	.69**	.72**	-.66**	1.00	-.70**
FRINC	.04	-.47**	-.48**	.57**	-.70**	1.00
<u>BI</u>						
SQ	1.00	.54**	.49**	-.20	.58**	-.04
DSA	.54**	1.00	.94**	-.08	.77**	-.24
DSCR	.49**	.94**	1.00	.04	.76**	-.29
DSINC	-.20	-.08	.04	1.00	.04	.39**
FRDS	.58**	.77**	.76**	.04	1.00	-.18
FRINC	-.04	-.24	-.29	.39**	-.18	1.00

(Table Continues)

Table 13 -- continued

	SQ	DSA	DSCR	DSINC	FRDS	FRINC
<u>Total</u>						
SQ	1.00	.77**	.73**	-.29**	.75**	-.26**
DSA	.77**	1.00	.97**	-.33**	.89**	-.42**
DSCR	.73**	.97**	1.00	-.28**	.89**	-.45**
DSINC	-.29**	-.28**	-.28**	1.00	-.26*	.47**
FRDS	.75**	.89**	.89**	-.26*	1.00	-.41**
FRINC	-.26**	-.45**	-.45**	.47**	-.41**	1.00

Note. NBI = Non-brain-injured; BI = Brain-injured
 Total = Total Sample; SQ = Sequential Factor; DSA =
 Digit Symbol A Raw Score; DSCR = Digit Symbol A Correct
 Symbols; DSINC = Digit Symbol A Incorrect Symbols
 FRDS = Free Recall Digit Symbol Raw Score; FRINC = Free
 Recall Digit Symbol Incorrect Symbols

* $p < .05$

** $p < .01$

Table 14

Summary of Descriptive Test Results for GroupMembership Based on Category Test Subtest 7 Error Score

Variable	Mean	SD	N
<hr/>			
Sequential Factor			
Group 1	101.78	15.96	68
Group 2	76.23	11.13	26
Digit Symbol A - Raw Score			
Group 1	17.66	8.01	68
Group 2	5.81	6.82	26
Digit Symbol A - Correct Symbols			
Group 1	6.31	2.70	68
Group 2	2.50	2.37	26
Digit Symbol A - Incorrect Symbols			
Group 1	1.13	1.38	68
Group 2	2.12	2.83	26

(Table Continues)

Table 14 -- continued

Variable	Mean	SD	N
Free Recall Digit Symbol Raw Score			
Group 1	7.13	2.25	68
Group 2	4.04	2.32	26
Free Recall Digit Symbol Incorrect Symbols			
Group 1	.85	1.24	68
Group 2	1.27	1.37	26

Note. Group 1 = Category Test Total Error Score < 51;
Group 2 = Category Test Total Error Score > 51.

Table 15

Summary of Univariate F-Tests for Group Membership
Based on Category Test Subtest 7 Error Score

Variable	Error SS	Df	Error MS	F
Sequential Factor	20150.31	1	219.03	56.05**
Digit Symbol A - Raw Score	5455.26	1	59.30	44.57**
Digit Symbol A - Correct Symbols	627.01	1	6.82	40.04**
Digit Symbol A - Incorrect Symbols	328.46	1	3.57	5.09*
Free Recall Digit Symbol Raw Score	472.77	1	5.14	35.04**
Free Recall Digit Symbol Incorrect Symbols	149.64	1	1.63	2.00

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

Table 16

Summary of Point-Biserial Correlations For Group
Membership Based on Category Test Subtest 7 Error Score

	SQ	DSA	DSCR	DSINC	FRDS	FRINC
Group						
Membership	-.62**	-.57**	-.55**	.23*	-.53**	.15

* $p < .05$

** $p < .01$

Note. SQ = Sequential Factor; DSA = Digit Symbol A Raw Score; DSCR = Digit Symbol A Correct Symbols; DSINC = Digit Symbol A Incorrect Symbols; FRDS = Free Recall Digit Symbol Raw Score; FRINC = Free Recall Digit Symbol Incorrect Symbols;

APPENDIX C
ILLUSTRATION

Figure 1

Representation of Mean Performance on Three Versions of
the Category Test Total Score

Note. CAT-208 = Category Test (Reitan & Wolfson, 1985); BCT = Booklet Category Test (DeFilippis & McCampbell, 1979); CV-CAT = Computerized Version of the Category Test (Miller, 1989)

REFERENCES

- Adams, K. M., & Heaton, R. K. (1985). Automated interpretation of neuropsychological test data. Journal of Clinical and Consulting Psychology, 53(6), 790-802.
- Adams, K. M., Kvale, V. I., & Keegan, J. F. (1984). Performance of three automated systems for neuropsychological interpretation based on two representative tasks. Journal of Clinical Neuropsychology, 6, 413-431.
- Anastasi, A. (1988). Psychological testing (6th ed.). New York, NY: Macmillan Publishing Company.
- Anderson, H. E., Kern, F. E., & Cook, C. (1967). Correlational and normative data for the Progressive Matrices with retarded populations. Journal of Psychology, 67, 221-224.
- Anderson, H. E., Kern, F. E., & Cook, C. (1968). Sex, brain damage, and race effects in the Progressive Matrices with retarded populations. Journal of Social Psychology, 78, 207-211.
- Anthony, W. Z., Heaton, R. K., & Lehman, R. A. W. (1980). An attempt to cross-validate two actuarial systems for neuropsychological test interpretation. Journal of Consulting and Clinical Psychology, 48, 317-326.

- Baltes, P. B., Reese, H. W., & Nesselroade, J. R. (1988). Life-span developmental psychology: Introduction to research methods. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Barnes, G. W., & Lucas, G. (1974). Cerebral dysfunction vs. psychogenesis in Halstead-Reitan tests. The Journal of Nervous and Mental Disease, 158(1), 50-60.
- Beaumont, J. G. (1975). The validity of the Category Test administered by on-line computer. Journal of Clinical Psychology, 31, 458-462.
- Beck, A. T., & Steer, R. A. (1987). Beck Depression Inventory Manual. San Antonio, TX: The Psychological Corporation Harcourt Brace Jovanovich, Inc.
- Benton, A. L. (1968). Differential behavioral effects in frontal lobe disease. Neuropsychologia, 6, 53-60.
- Benton, A. L. (1959). Right-Left Discrimination and Finger Localization: Development and pathology. New York, NY: Hoeber-Harper.
- Benton, A. L., & Hamsher, K. deS. (1983). Multilingual Aphasia Examination. Iowa City, IA: AIA Associates.
- Bertram, K. W., Abeles, N. & Snyder, P. J. (1990). The role of learning in performance on Halstead's Category Test. The Clinical Neuropsychologist, 4(3), 244-252.
- Bigler, E. D. (1990). Neuropathology of traumatic brain injury. In E. D. Bigler (Ed.), Traumatic brain injury:

Mechanisms of damage, assessment, intervention, and outcome. Austin, TX: PRO-ED.

- Bigler, E. D., Steinman, D. R., & Newton, J. S. (1981).
Persisting symptoms after mild head injury: A review of
the postconcussive syndrome. Journal of Clinical and
Experimental Neuropsychology, 8, 323-346.
- Bond, J. A., & Buchtel, H. A. (1984). Comparison of the
Wisconsin Card Sorting Test and the Halstead Category
Test. Journal of Clinical Psychology, 40(5), 1251-1255.
- Bornstein, R. A. (1986). Contribution of various
neuropsychological measures to detection of frontal lobe
impairment. The International Journal of Clinical
Neuropsychology, 8(1), 18-22.
- Bornstein, R. A., & Leason, M. (1985). Effects of
localized lesions on the Verbal Concept Attainment Test.
Journal of Clinical and Experimental Neuropsychology,
7(4), 421-429.
- Boyle, G. J. (1988). What does the neuropsychological
Category Test measure? Archives of Clinical
Neuropsychology, 3, 69-76.
- Boyle, G. J. (1986). Clinical neuropsychological
assessment: Abbreviating the Halstead Category Test of
brain dysfunction. Journal of Clinical Psychology,
42(4), 615-625.
- Boyle, G. J. (1975). Shortened Halstead Category Test.
Australian Psychologist, 10(1), 81-84.

- Brandon, A. D., & Chavez, E. L. (1985). Order and delay effects on neuropsychological test presentation: The Halstead Category and Wisconsin Card Sorting Test. The International Journal of Clinical Neuropsychology, 8(3), 152-153.
- Brooks, D. N. (1983). Disorders of memory. In M. Rosenthal, E. R. Griffith, M. R. Bond, & J. R. Miller (Eds.), Rehabilitation of the head injured adult. Philadelphia, PA: Davis.
- Calsyn, D. A., O'Leary, M. R., & Chaney, E. F. (1980). Shortening the Category Test. Journal of Consulting and Clinical Psychology, 48(6), 788-789.
- Chadwick, O., Rutter, M., Brown, G., Schaffner, D., & Traub, M. (1981). A prospective study of children with head injuries: II. Cognitive sequelae. Psychological Medicine, 11, 49-61.
- Chadwick, O., Rutter, M., Schaffner, D., & Shrout, P. E. (1981). A prospective study of children with head injuries: IV. Specific cognitive deficits. Journal of Clinical Neuropsychology, 3, 101-120.
- Charter, R. A., Adkins, T. G., Alekoumbides, A., & Seacat, G. F. (1987). Reliability of the WAIS, WMS, and Reitan Battery: Raw scores and standardized scores corrected for age and education. The International Journal of Clinical Neuropsychology, 9(1), 28-32.

- Childs, N. L., Mercer, W. N., & Childs, H. W. (1993). Accuracy of diagnosis of persistent vegetative state. Neurology, 43(8), 1465-1467.
- Cochran, M. L., & Pedrini, D. T. (1969). The concurrent validity of the 1965 WRAT with adult retardates. American Journal of Mental Deficiency, 73, 654-656.
- Cohen, J. (1977). Statistical power analysis for the behavioral sciences. (Rev. ed.). New York, NY: Academic Press.
- Cohen, J., & Cohen, P. (1975). Applied multiple regression/correlation analysis for the behavioral sciences. Hillsdale, NJ: Erlbaum Associates.
- Cohen, P. (1982). To be or not to be: Control and balancing of Type I and Type II errors. Evaluation and Program Planning, 5, 247-253.
- Collins, M., & Odell, K. (1986). Computerization of a traditional test for nonverbal visual problem solving. Cognitive Rehabilitation, 4(5), 16-18.
- Corrigan, J. D., & Hinkeldey, N. S. (1988). Patterns of performance within the Halstead-Reitan Neuropsychological Test Battery. The International Journal of Clinical Neuropsychology, 10(1), 25-34.
- Corrigan, J. D., Agresti, A. A., & Hinkeldey, N. S. (1987). Psychometric characteristics of the Category Test: Replication and extension. Journal of Clinical Psychology, 43(3), 368-376.

- Coutts, R. L., Lichstein, L., Bermudez, J. M., Daigle, M., Mann, D. P., Charbonnel, T. S., Michaud, R., & Williams, C. R. (1987). Treatment assessment of learning disabled children: Is there a role for frequently repeated neuropsychological testing? Archives of Clinical Neuropsychology, 2, 237-244.
- Cuevas, J. L., & Osterich, H. (1990). Cross-cultural evaluation of the Booklet Version of the Category Test. International Journal of Clinical Neuropsychology, 12(3-4), 187-190.
- Cullum, C. M., Kuck, J., & Ruff, R. M. (1990). Neuropsychological assessment of traumatic brain injury in adults. In E. D. Bigler, (Ed.), Traumatic brain injury: Mechanisms of damage, assessment, intervention, and outcome. Austin, TX: PRO-ED, Inc.
- Cullum, C. M., Steinman, D. R., & Bigler, E. D. (1984). Relationship between fluid and crystallized cognitive functions using Category Test and WAIS scores. The International Journal of Clinical Neuropsychology, 6(3), 172-174.
- Davidoff, G., Morris, J., Roth, E., & Bleiberg, J. (1985). Cognitive dysfunction and mild closed head injury in traumatic spinal cord injury. Archives of Physical Medicine and Rehabilitation, 66, 489-491.

- DeFilippis, N. A. (1993). Category Test: Computer Version Research Edition. Psychological Assessment Resources, Inc. Spring Catalogue.
- DeFilippis, N. A., & McCampbell, E. (1979). The Booklet Category Test: Research and clinical form (Manual). Odessa, FL: Psychological Assessment Resources, Inc.
- DeFilippis, N. A., McCampbell, E., & Rogers, P. (1979). Development of a booklet form of the Category Test: Normative and validity data. Journal of Clinical Neuropsychology, 1, 339-342.
- Dodrill, C. B., & Troupin, A. S. (1975). Effects of repeated administrations of a comprehensive neuropsychological battery among chronic epileptics. The Journal of Nervous and Mental Disease, 161(3), 185-190.
- Dunn, E. J., Margolis, R. B., & Taylor, J. M. (1985). Short forms of the Category Test: Applications for geriatric patients. The International Journal of Clinical Neuropsychology, 7(1), 29-31.
- Dunn, L. M. (1965). Expanded manual for the Peabody Picture Vocabulary Test. Minneapolis, MN: American Guidance Service.
- Dunn, O. J. (1961). Multiple comparisons among means. Journal of the American Statistical Association, 56, 52-64.

- Edwards, B. T., & Klein, M. (1984). Comparison of the WAIS and the WAIS-R with Ss of high intelligence. Journal of Clinical Psychology, 40, 300-302.
- Ernst, J. (1987). Neuropsychological problem-solving skills in the elderly. Psychology and Aging, 2(4), 363-365.
- Everett, P. S. (1984). The relationship between cognitive function and liver function in alcoholism. British Journal of Psychiatry, 144, 521-524.
- Finlayson, M. A., J., Sullivan, J. F., & Alfano, D. P. (1986). Halstead's Category Test: Withstanding the test of time. Journal of Clinical and Experimental Neuropsychology, 8(6), 706-709.
- Fisher, G. M., Kilman, B. A., & Shotwell, A. M. (1961). Comparability of intelligence quotients of mental defectives on the WAIS and the 1960 revision of the Stanford-Binet. Journal of Consulting Psychology, 25, 192-195.
- Glyshaw, K. J. (1990). Relationship between the Category Test and the Picture Arrangement subtest of the WAIS-R. International Journal of Neuroscience, 51, 79-81.
- Golden, C. J., Hammeke, T. A., & Purisch, A. D. (1985). The Luria-Nebraska Neuropsychological Battery. Los Angeles, CA: Western Psychological Services.
- Golden, C. J., Osmon, D. C., Moses, J. A., Jr., & Berg, R. A. (1981). Interpretation of the Halstead-Reitan

- Neuropsychological Test Battery. New York, NY: Grune & Stratton.
- Goldstein, G. (1990). Neuropsychological heterogeneity in schizophrenia: A consideration of abstraction and problem-solving abilities. Archives of Clinical Neuropsychology, 5, 251-264.
- Goldstein, G., & Shelly, C. H. (1972). Statistical and normative studies of the Halstead Neuropsychological Test Battery relevant to a neuropsychiatric hospital setting. Perceptual and Motor Skills, 34, 603-620.
- Goldstein, G., & Zubin, J. (1990). Neuropsychological differences between young and old schizophrenics with and without associated neurological dysfunction. Schizophrenia Research, 3, 117-126.
- Granick, S. (1971). Brief tests and their interrelationships as intellectual measures of aged subjects. American Psychological Association, Proceedings, 79, 599-600.
- Gregory, R. J., Paul, J., & Morrison, M. W. (1979). A short form of the Category Test for adults. Journal of Clinical Psychology, 35(4), 795-798.
- Gronwall, D. M. A. (1977). Paced Auditory Serial Addition Task: A measure of recovery from concussion. Perceptual and Motor Skills, 44, 367-373.

- Guertin, W. H., Ladd, C. E., Frank, G. H., Rabin, A. I., & Hiester, D. S. (1966). Research with the WAIS; 1960-1965. Psychological Bulletin, 66, 385-409.
- Hall, J.C. (1957). Correlation of a modified form of Raven's Progressive Matrices (1938) with the WAIS. Journal of Consulting Psychology, 21, 23-26.
- Halstead, W. C. (1947). Brain and intelligence. Chicago, IL: The University of Chicago Press.
- Harris, A. J. (1947). Harris Tests of Lateral Dominance, manual of directions for administration and interpretation. New York, NY: Psychological Corporation.
- Heaton, R. K. (1981). Wisconsin Card Sorting Test Manual. Odessa, FL: Psychological Assessment Resources.
- Heaton, R. K., & Adams, K. M. (1987). Potential versus current reality of automation in neuropsychology: Reply to Kleinmuntz. Journal of Consulting and Clinical Psychology, 55(2), 268-269.
- Heaton, R. K., Grant, I., Anthony, W. Z., & Lehman, R. A. W. (1981). A comparison of clinical and automated interpretation of the Halstead-Reitan Battery. Journal of Clinical Neuropsychology, 3, 121-141.
- Hesselbrock, M. N., Weidenman, M. A., & Reed, H. B. C. (1985). Effects of age, sex, drinking history and antisocial personality on neuropsychology of alcoholics. Journal of Studies on Alcohol, 46(4), 313-320.

- Horton, A. M., & Siegel, E. (1990). Comparison of multiple sclerosis and head trauma patients: A neuropsychological pilot study. International Journal of Neuroscience, 53, 213-215.
- Jastak, J. F., & Jastak, S. R. (1965). The Wide Range Achievement Test Manual. Wilmington, DE: Guidance Associates.
- Jennett, B. (1986). Head trauma. In A. K. Asbury, G. M. McKhann, & W. I. McDonald, W. I. (Eds.), Disease of the nervous system. Philadelphia, PA: W. B. Saunders
- Jurjevich, R. M. (1967). Intellectual assessment with Gorham's Proverbs Test, Raven's Progressive Matrices and WAIS. Psychological Reports, 20, 1285-1286.
- Kangas, J. A., & Bradway, K. P. (1971). Intelligence at middle age. Developmental Psychology, 5, 333-337.
- Kaplan, E., Fein, D., Morris, R., & Delis, D. C. (1991). WAIS-R NI: Manual. New York, NY: The Psychological Corporation Harcourt Brace Jovanovich, Inc.
- Kaufman, A. S. (1990). Assessing adolescent and adult intelligence. Boston, MA: Allyn & Bacon, Inc.
- Kellner, C. H., Rubinow, D. R., & Post, R. M. (1986). Cerebral ventricular size and cognitive impairment in depression. Journal of Affective Disorders, 10, 215-219.
- Kelly, M. P., Montgomery, M. L., Fellman, E. S., & Webb, W. W. (1984). Wechsler Adult Intelligence Scale and Wechsler Adult Intelligence Scale - Revised in a

- neurologically impaired population. Journal of Clinical Psychology, 40, 788-791.
- Kennedy, W. A., Willcutt, H., & Smith, A. (1963). Wechsler profiles of mathematically gifted adolescents. Psychological Reports, 12, 259-262.
- Kilpatrick, D. G. (1970). The Halstead Category Test of brain dysfunction: Feasibility of a short form. Perceptual and Motor Skills, 30, 577-578.
- Kleinmuntz, B. (1987). Automated interpretation of neuropsychological test data: Comment on Adams and Heaton. Journal of Consulting and Clinical Psychology, 55(2), 266-267.
- Klonoff, H. (1971). Factor analysis of a neuropsychological battery for children aged 9 to 15. Perceptual and Motor Skills, 32, 603-616.
- Knights, R. M., & Watson, P. (1968). The use of computerized test profiles in neuropsychological assessment. Journal of Learning Disabilities, 12, 6-19.
- Kolb, B., & Whishaw, I. Q. (1985). Fundamentals of human neuropsychology (2nd. ed.). New York, NY: W. H. Freeman and Company.
- Kroske, W. H., Fretwell, L. N., & Cupp, M. E. (1965). Comparison of the Kahn Intelligence Tests, Experimental Form, Stanford Binet, and the WAIS for familial retardates. Perceptual and Motor Skills, 21, 428.

- Kupke, T. (1983). Effects of subject sex, examiner sex, and test apparatus on Halstead Category and Tactual Performance Tests. Journal of Consulting and Clinical Psychology, 51(4), 624-626.
- Laatsch, L. (1983). Development of a memory training program. Cognitive Rehabilitation, 1(4), 15-18.
- Labreche, T. M. (1983). The Victoria Revision of the Halstead Category Test. Unpublished doctoral dissertation. University of Victoria, British Columbia, Canada. Cited in Spreen, O., & Strauss, E. (1991). A compendium of neuropsychological tests: Administration, norms, and commentary. New York, NY: Oxford University Press.
- Lansdell, H., & Donnelly, E. F. (1977). Factor analysis of the Wechsler Adult Intelligence Scale subtests and the Halstead-Reitan Category and Tapping Tests. Journal of Consulting and Clinical Psychology, 45(3), 412-416.
- Leininger, B. E., Gramling, S. E., Farrell, A. D., Kreutzer, J. S., & Peck, E. A., III. (1990). Neuropsychological deficits in symptomatic minor head injury patients after concussion and mild concussion. Journal of Neurology, Neurosurgery, and Psychiatry, 53, 293-296.
- Levin, H. S., Benton, A. L., & Grossman, R. G. (Eds.). (1982). Neurobehavioral consequences of closed head injury. New York, NY: Oxford University Press.

Levin, H. S., & Eisenberg, H. M. (1979).

Neuropsychological impairment after closed head injury in children and adolescents. Journal of Pediatric Psychology, 4, 389-402.

Lezak, M. D. (1983). Neuropsychological assessment (2nd ed.). New York, NY: Oxford University Press.

Lin, Y. G., & Rennick, P. M. (1974). Correlations between performance on the Category Test and the Wechsler Adult Intelligence Scale in an epileptic sample. Journal of Clinical Psychology, 30, 62-65.

Luria, A. R. (1973). The working brain: An introduction to neuropsychology. New York, NY: Basic Books.

Lynch, W. J. (1983). The use of a word processor in language rehabilitation. Cognitive Rehabilitation, 1(6), 20-23.

MacInnes, W. E., Forch, J. R., & Golden, C. J. (1981). A cross-validation of a booklet form of the Category Test. Clinical Neuropsychology, 3, 3-5.

McKerracher, D. W., & Scott, J. (1966). IQ scores and the problem of classification. British Journal of Psychiatry, 112, 537-541.

Matarazzo, J. D., Wiens, A. N., Matarazzo, R. G., & Goldstein, S. G. (1974). Psychometric and clinical test-retest reliability of the Halstead Impairment Index in a sample of healthy, young, normal men. The Journal of Nervous and Mental Disease, 158(1), 37-49.

- Matarazzo, J. D., Matarazzo, R. G., Wiens, A. N., Gallo, A. E., & Klonoff, H. (1976). Retest reliability of the Halstead Impairment Index in a normal, a schizophrenic, and two samples of organic patients. Journal of Clinical Psychology, 32(2), 338-349.
- McCaffrey, R. J., Ortega, A., Orsillo, S. M., Nelles, W. B., & Haase, R. F. (1992). Practice effects in repeated neuropsychological assessments. The Clinical Neuropsychologist, 6(1), 32-42.
- McCampbell, E., & DeFilippis, N. A. (1979). The development of a booklet form of the Category Test: A preliminary report. Clinical Neuropsychology, 1, 33-35
- McLeod, H. N., & Rubin, J. (1962). Correlation between Raven Progressive Matrices (1956) and the WAIS. Journal of Consulting Psychology, 62, 190-191.
- Miller, D. C. (1993). Development of the Color Version of the Computerized Version of the Category Test. Personal communication.
- Miller, D. C. (1989). Relationships among three levels of measuring planning: Electrophysiological - event-related potentials, neuropsychological - the Category Test, and psychological - PASS scales in adolescent males. Unpublished doctoral dissertation. Ohio State University.
- Mitchell, R. E., Grandy, T. G., & Lupo, J. V. (1986). Comparison of the WAIS and WAIS-R in the upper ranges of

IQ. Professional Psychology: Research and Practice, 17, 82-83.

Mitrushina, M., Satz, P., Gordon, D., & Perez, J. (1991). Practice effects on repeated neuropsychological testing in the elderly. Poster presented at the Annual Meeting Scientific Program of the American Psychological Association. San Francisco, CA.

Moerland, K. L. (1985). Validation of computer based test interpretations: Problems and prospects. Journal of Consulting and Clinical Psychology, 53, 816-825.

Moerland, M. C., Aldenkamp, A. P., & Alpherts, W. C. J. (1986). A neuropsychological test battery for the Apple II-E. International Journal of Man-Machine Studies, 25, 453-467.

Morrison, P. R., & Gates, G. R. (1988). Assessment of a microcomputer-based version of the Austin Maze. The Journal of General Psychology, 115(3), 307-314.

Moses, J. A. (1985). Internal consistency of standard and short forms of three itemized Halstead-Reitan Neuropsychological Battery Tests. The International Journal of Clinical Neuropsychology, 7(3), 164-166.

Nussbaum, N. L., & Bigler, E. D. (1989). Halstead-Reitan Neuropsychological Test Batteries For Children. In C. R. Reynolds, & E. Fletcher-Janzen (Eds.), Handbook of Clinical Child Neuropsychology. New York, NY: Plenum Press.

- Orme, J. E. (1968). A comment on estimating WAIS IQs from Progressive Matrices. Journal of Clinical Psychology, 24, 94-95.
- Pendleton, M. G., & Heaton, R. K. (1982). A comparison of the Wisconsin Card Sorting Test and the Category Test. Journal of Clinical Psychology, 38(2), 392-396.
- Prigatano, G. P. (1990). Effective traumatic brain injury rehabilitation: Team/patient interaction. In E. D. Bigler (Ed.), Traumatic brain injury: Mechanisms of damage, assessment, intervention, and outcome. Austin, TX: PRO-ED.
- Pringle, R. K., & Haanstad, M. (1971). Estimating WAIS IQs from Progressive Matrices and Shipley Hartford scores. Journal of Clinical Psychology, 27, 479-481.
- Rattan G., Dean, R. S., & Fischer, W. E. (1986). Response time as a dependent measure on the Category Test of the Halstead-Reitan Neuropsychological Test Battery. Journal of Clinical Neuropsychology, 1, 175-182.
- Raven, J. C. (1965). Guide to using the Coloured Progressive Matrices. New York, NY: The Psychological Corporation.
- Rawlings, D. B., & Crewe, N. M. (1992). Test-retest practice effects and test score changes of the WAIS-R in recovering traumatically brain-injured survivors. The Clinical Neuropsychologist, 6(4), 415-430.

- Reitan, R. M., & Davison, L. A. (1974). Clinical neuropsychology: Current status and applications. Washington, DC: W. H. Winston & Sons.
- Reitan, R. M., & Herring, S. (1985). A short screening device for identification of cerebral dysfunction in children. Journal of Clinical Psychology, 41(5), 643-650.
- Reitan, R. M., & Wolfson, D. (1985). The Halstead-Reitan Neuropsychological Test Battery: Theory and clinical interpretation. Tucson, AZ: Neuropsychology Press.
- Rey, A. (1964). L'examen Clinique en Psychologie. Paris: Presses Universitaires de France.
- Rey, A. (1941). L'examen psychologique dans les cas d'encephalopathie traumatique. Archives de Psychologie, 28, 286-340.
- Rogers, D. L., & Osborne, D. (1984). Comparison of the WAIS and WAIS-R at different ages in a clinical population. Psychological Reports, 54, 951-956.
- Roth, E., Davidoff, G., Thomas, P., Doljanac, R., Dijkers, M., Berent, S., Morris, J., & Yarkony, G. (1989). A controlled study of neuropsychological deficits in acute spinal cord injury patients. Paraplegia, 27, 480-489.
- Rothke, S. (1986). The role of set shifting cues on the Wisconsin Card Sorting Test and Halstead Category Test. The International Journal of Clinical Neuropsychology, 8(1), 11-14.

- Rothman, K. J. (1990). No adjustments are needed for multiple comparisons. Epidemiology, 1(1), 43-46.
- Rothman, K. J. (1986). Modern epidemiology. Boston, MA: Little, Brown and Company.
- Russell, E. W., & Levy, M. (1987). Revision of the Halstead Category Test. Journal of Consulting and Clinical Psychology, 55(6), 898-901.
- Russell, E. W., & Barron, J. H. (1989). A difference that is not a difference: Reply to Vanderploeg and Logan. Journal of Consulting and Clinical Psychology, 57(2), 317-318.
- Ryan, J. J., Rosenberg, S. J., & Prifitera, A. (1983). On substituting the WAIS-R for the WAIS in neuropsychological assessment: A caution for clinicians. Journal of Psychology, 115, 131-134.
- Ryan, J. J., Rosenberg, S. J., & Heilbronner, R. L. (1984). Comparative relationship of the Wechsler Adult Intelligence Scale - Revised (WAIS-R) and the Wechsler Adult Intelligence Scale (WAIS) to the Wechsler Memory Scale (WMS). Journal of Behavioral Assessment, 6, 37-43.
- Sarazin, F. F. A., & Spreen, O. (1986). Fifteen-year stability of some neuropsychological tests in learning disabled subjects with and without neurological impairment. Journal of Clinical and Experimental Neuropsychology, 8(3), 190-200.

- Sattler, J. M. (1990). Assessment of children (3rd ed., Rev reprint). San Diego, CA: Author.
- Seidenberg, M., Giordani, B., Berent, S., & Boll, T. J. (1983). IQ level and performance on the Halstead-Reitan Neuropsychological Test Battery for older children. Journal of Consulting and Clinical Psychology, 51(3), 406-413.
- Shaw, D. J. (1967). Estimating WAIS IQs from Progressive Matrices. Journal of Clinical Psychology, 23, 184-185.
- Sherrill, R. E. (1987). Options for shortening Halstead's Category Test for adults. Archives of Clinical Neuropsychology, 2, 343-352.
- Sherrill, R. E. (1985). Comparison of three short forms of the Category Test. Journal of Clinical and Experimental Neuropsychology, 7(3), 231-238.
- Shore, C., Shore, H., & Phil, R. O. (1971). Correlations between performance on the Category Test and the Wechsler Adult Intelligence Scale. Perceptual and Motor Skills, 32, 70.
- Shute, G. E., & Huertas, V. (1990). Development variability in frontal lobe function. Developmental Neuropsychology, 6(1), 1-11.
- Simon, C. L., & Clopton, J. R. (1984). Comparison of WAIS and WAIS-R scores of mildly and moderately retarded adults. American Journal of Mental Deficiency, 89, 301-303.

- Skenazy, J. A., & Bigler, E. D. (1984). Neuropsychological findings in diabetes mellitus. Journal of Clinical Psychology, 40(1), 246-259.
- Slay, D. K. (1984). A portable Halstead-Reitan Category Test. Journal of Clinical Psychology, 40(4), 1023-1027.
- Spreeen, O., & Strauss, E. (1991). A compendium of neuropsychological tests: Administration, norms, and commentary. New York, NY: Oxford University Press.
- Summers, M. N., & Boll, T. J. (1987). Comparability of a short booklet version and the traditional form of the Category Test. The International Journal of Clinical Neuropsychology, 9(4), 158-161.
- Swiercinsky, D. P. (1978). Manual for the Adult Neuropsychological Evaluation. Springfield, IL: Charles C. Thomas.
- Swiercinsky, D. P. (1979). Factorial pattern description and comparison of functional abilities in neuropsychological assessment. Perceptual and Motor Skills, 48, 231-241.
- Sydiah, D. (1967). Prediction of WAIS IQ for psychiatric patients using the Ammons Full Range Picture Vocabulary and Raven Progressive Matrices. Psychological Reports, 20, 823-826.
- Taylor, D. J., Hunt, C., & Glaser, B. (1990). A crossvalidation of the Revised Category Test.

Psychological Assessment: A Journal of Clinical and Consulting Psychology, 2(4), 486-488.

Taylor, J. M., Goldman, H., Leavitt, J., & Kleinmen, K. M. (1984). Limitations of the brief form of the Halstead Category Test. Journal of Clinical Neuropsychology, 6(3), 341-344.

Terman, L. M., & Merrill, M. A. (1960). Stanford-Binet Intelligence Scale: Manual for the third revision, Form L-M. Boston, MA: Houghton Mifflin.

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). Guide for administering and scoring the Stanford-Binet Intelligence Scale: Fourth Edition. Chicago, IL: The Riverside Publishing Company.

Tupper, D. E. (1990). Some observations on the use of the Woodcock-Johnson Tests of Cognitive Ability in adults with head injury. Journal of Learning Disabilities, 23(5), 306-310.

Vanderploeg, R. D., & Logan, S. G. (1989). Comparison of the Halstead Category Test and the Revised Category Test: Comment on Russell and Levy. Journal of Consulting and Clinical Psychology, 57(2), 315-316.

Walsh, K. W. (1978). Neuropsychology: A clinical approach. Edinburgh: Chruchill Livingstone.

Wechsler, D. (1939). The measurement of adult intelligence. Baltimore, MD: Williams & Wilkins.

- Wechsler, D. (1945). A standardized memory scale for clinical use. Journal of Psychology, 19, 87-95.
- Wechsler, D. (1949). Manual for the Wechsler Intelligence for Children. New York, NY: Psychological Corporation.
- Wechsler, D. (1955). Manual for the Wechsler Adult Intelligence Scale. New York, NY: The Psychological Corporation.
- Wechsler, D. (1958). The measurement and appraisal of adult intelligence (4th ed.). Baltimore, MD: Williams & Wilkins.
- Wechsler, D. (1981). Wechsler Adult Intelligence Scale-Revised: Manual. Cleveland, OH: The Psychological Corporation Harcourt Brace Jovanovich, Inc.
- Wetzel, L., & Boll, T. J. (1987). Short Category Test (Card Form). Los Angeles, CA: Western Psychological Services.
- Willis, L., Yeo, R. A., Thomas, P., & Garry, P. J. (1988). Differential declines in cognitive function with aging: The possible role of health status. Developmental Neuropsychology, 4(1), 23-28.
- Winer, B. J. (1971). Statistical principles in experimental design. New York, NY: McGraw-Hill Book Company.
- Woodcock, R. W., & Mather, N. (1989). Woodcock-Johnson Tests of Achievement. Allen, TX: DLM Teaching Resources.

- Yeudall, L. T., Reddon, J. R., Gill, D. M., & Stefanyk, W. O. (1987). Normative data for the Halstead-Reitan Neuropsychological tests stratified by age and sex. Journal of Clinical Psychology, 43(3), 346-367.
- Zimmerman, R. L., Woo-Sam, J. M., & Glasser, A. J. (1973). Clinical interpretation of the Wechsler Adult Intelligence Scale. New York, NY: Grune & Stratton.