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THE RIGHT HEMISPHERE HYPOTHESIS:
NEUROPSYCHOLOGICAL TEST PERFORMANCE
IN THE ABLE ELDERLY

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THE RIGHT HEMISPHERE HYPOTHESIS: NEUROPSYCHOLOGICAL TEST PERFORMANCE IN THE ABLE ELDERLY

By

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ABSTRACT

THE RIGHT HEMISPHERE HYPOTHESIS: NEUROPSYCHOLOGICAL TEST PERFORMANCE IN THE ABLE ELDERLY

By

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It has been suggested that the right hemisphere ages more rapidly than the left. A right hemisphere hypothesis (Klisz, 1978) has been put forth to account for this decline in cognitive abilties as a result of aging. An age- and sex-stratified sample ($\underline{N}$ = 36, ages 55-84) of able-elderly persons were individually administered a battery of neuropsychological tests, each of which represented either overall functioning, right hemisphere functioning, or left hemisphere functioning. A modest decline of overall functioning abilities were found with advancing age (beta = –.36, $\underline{R}^2$change = .12, $p \leq .05$). Furthermore, results supported the conclusion that among older individuals, measurable neuropsychological changes occur in both right (beta = –.40, $\underline{R}^2$change = .15, $p \leq .05$) and left (beta = –.50, $\underline{R}^2$change = .23, $p \leq .005$) hemisphere abilities. Finally, in an effort to investigate general decline as a consequence of aging, it was hypothesized that measures of right hemisphere functioning would act as a mediator and account for the decline in overall functioning abilities. Contrary to expectations, only measures of left hemisphere functioning significantly accounted for this decline (beta = .27, $\underline{R}^2$change = .33, $p \leq .05$).

In memory of my grandmother, Esther Berman Mintz

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INTRODUCTION

Aging is often thought of as a degenerative process. It is a commonly held belief that as humans age they lose certain capabilities. Research on the relationships between aging and intellectual functioning had its inception nearly 100 years ago in comparisons between adults and children. This area of research has interested investigators in a multitude of fields.

Cerebral Laterality

In 1874, Hughlings Jackson proposed that the two cerebral hemispheres have different functional roles. The left hemisphere is responsible for mediating verbal activity, and the right hemisphere is devoted to visuoperceptive, visuospatial, and visuoconstructive functions (Benton, 1977). Furthermore, the right hemisphere is specialized for at least four major areas of behavior: complex and nonlinguistic perceptual tasks, spatial distribution of attention, emotional behavior, and paralinguistic aspects of communication (Mesulam, 1985).

In addition, the right and left hemispheres are anatomically different. The planum temporal (the posterior superior surface of the temporal lobe) is significantly larger on the left then on the right hemisphere (Benson & Zaidel, 1985). This area of the left hemisphere corresponds to the auditory association cortex (Wernicke's region); the area dominant for language function. Moreover, another language area (Broca's region) located in the inferior frontal area is also larger on the left hemisphere.

Injuries to the left hemisphere are associated primarily with language deficits. Common syndromes following left hemisphere damage include alexia- a loss of ability to ascribe meaning to letter symbols. Right hemisphere injuries involve visual-spatial and visual-perceptual functions. Common syndromes following right hemisphere damage include: difficulty in recognizing familiar environments, impairment of discrimination of faces, dressing disturbance, visual hallucination, and palinopsia. However, for some activities, both hemispheres must participate (Benson & Zaidel, 1985).

Diffuse Cortical Atrophy

It has been suggested that the psychological effects of aging resemble those of progressive brain damage mainly because the kinds of abilities that differentiate between brain damaged and non-brain damaged patients also distinguish between young and old individuals.

Goldstein and Shelly (1975), assumed a similarity between aging and diffuse brain damage and compared young brain damaged, young non-brain damaged, old brain damaged, and old non-brain damaged subjects. They hypothesized that there would be little difference between the performance of older groups and a large difference between the performance of the younger groups. Their rationale was that if the effects of aging are similar to those of diffuse brain damage, then the magnitude of the differences found between individuals with and without diffuse brain damage should decline with age. However, no interaction effects were found, and the authors concluded that younger subjects performed better than older subjects and non-brain damaged subjects performed better than brain damaged patients. Thus, the relation between aging and brain damage appeared more additive than interactive; aging resembles brain damage in certain aspects, but not in others. Overall and Goreham (1972) tested the hypothesis that older persons increasingly poor performance was due to developing organic brain syndrome. They found that the pattern of change associated with normal old age is different from the pattern associated with brain syndrome in the elderly.

Borod and Goodglass (1980) used a dichotic listening paradigm to investigate aging and its effect on verbal and melodic hemispheric specialization. Their finding did not support the notion that there is an increasing advantage of the left hemisphere for processing of dichotic material. Instead, these authors found that there was an overall decline in accuracy with age for both linguistic and melodic material, consistent with the notion of a more uniform deterioration in cerebral cortical function.

Mittenberg, Seidenberg, O'Leary, and DiGiulio (1989) found that the functioning of both hemispheres showed equal sensitivity to the effects of aging. These authors attribute many of the contradictory earlier findings to methodological problems. The latter included using timed tests for right hemisphere measures but untimed tests when assessing left hemisphere competence; the use of highly practiced verbal skills as indicators of left hemisphere and unfamiliar tasks to measure right hemisphere function; the influence of age-correlated illness on measures of right hemisphere function; and the lack of differentiation between measures of frontal lobe and right hemisphere function. Thus, evidence of greater right hemisphere vulnerability to the aging process was not found in some of these studies. Moreover, Mittenberg et al. (1989) attribute age-related neuropsychological changes to frontal lobe vulnerability rather than right hemisphere abilities.

Kinsbourne (1974) proposed a "three-tier" model of cognitive deficit in the aging individual. This model held that an elderly person's damage may be more related to the overall amount of cerebral loss than to its precise location. Thus, through cortical thinning, the ability to reason, change set, and attend would be hindered in the aged. This uniform decline in all mental processes (three-tier model) predicts that a deficit on tests that draw primarily upon general reasoning power or "g" for correct performance should account for most of the test deficits in aging and dementia. The author concluded that old adults who were matched with young adults on vocabulary test scores fell far short in the tasks of right hemisphere function. Therefore, "normal" aging involves a progressive, diffuse depletion of cerebral neurons so that we see a uniform decline in efficiency in all mental processes represented by tests of fluid intelligence (Kinsbourne, 1974).

Elias and Kinsbourne (1974) studied male and female elderly (63-77) and young (23-33) subjects on verbal and nonverbal tasks. They found a general slowing for older groups of both sexes which could be interpreted as a general deterioration in both hemispheres. Additionally, these women showed an exaggerated age-dependent decline, suggesting a sex-related discrepancy.

Could there be a more specific component within the diffuse deterioration that contributes to or causes the appearance of general atrophy? Various research studies have found that patients with damage to the right hemisphere did consistently worse on nonverbal tests involving the manipulation of geometric figures, puzzle assembly, completion of missing parts of patterns and figures, and other tasks involving form, distance, and space relationships. Profound disturbances in orientation and awareness were also seen in right-hemisphere damaged patients (Springer & Deutsch, 1989).

A right hemisphere hypothesis (Klisz, 1978) has been put forth to account for the elderly individual's decline in cognitive abilities. This notion is based on similarities in normal elderly and right-hemisphere lesioned individuals on tests of cognitive performance. The right hemisphere has historically been referred to as the "minor" or secondary hemisphere in contrast to the more important, language-dominant, left hemisphere. However, over time, researchers discovered that the right hemisphere is a very important part of the human brain having its own specialized functions. Extensive research with brain-damaged patients supports the theory that the right hemisphere plays a major role in the performance of many non-verbal tasks (Ellis & Oscar-Berman, 1989). Therefore, it was also thought that test performance in the elderly should look like the performance characteristic of a group of chronic diffuse brain-damaged patients. However, caution should be taken because advanced age is often accompanied by a variety of systemic illness that may contribute to the apparent cognitive declines. Distinction between the effects of pathological change and normal aging is essential. Illness has been shown to produce an exaggeration of the Verbal IQ-Performance IQ discrepancy in a direction that may be interpreted as a right hemisphere dysfunction (Klisz, 1978).

Some researchers present evidence of changes in the structure and function of the brain in older adults. Among these changes are loss of neurons, structural alterations in surviving neurons, and changes in neurotransmitter release (Klisz, 1978). Kaplan (1980) stated that although there is a decrease in the overall weight and volume of the brain evident during old age, the dendritic branching and complexity of neurons increases during the 5th to 7th decade of life. She warned practitioners that age-related cognitive changes are relatively minor and do not interfere with the ability to lead an independent existence.

Can some of the changes in psychological functions observed in older people be attributed to changes that occur in brain structure and function during aging? More specifically, it has been stated that right hemisphere functions may decline more rapidly than left hemisphere functions in older people. Gur, Packer, Hungerbuhler, Reivich, Obrist, and Amarnek (1980) describe the left hemisphere as having a greater percentage of gray matter (nerve cells and nonmyelinated fibers), whereas as the right hemisphere consists of white matter (myelinated nerve fibers). These results suggest that verbal-analytic functions are subserved by a type of organization that emphasizes processing within regions (left hemisphere), while spatial-gestalt functions are subserved by processing that optimizes transfer across regions (right hemisphere). It is fair to say that the right hemisphere necessitates the coordination of many regions to carry out processing while left hemisphere activities are more independent. These processing styles have implications for damage or deterioration. Right hemisphere processing can be hindered if any region on a behavioral circuit is damaged while left hemisphere processing can cease only if damage occurs in a particular region. Thus, right hemisphere functions may be more easily impaired by brain damage or dysfunction than left hemisphere functions.

Right-Hemisphere Hypothesis

Over thirty years ago Horn and Cattell (1967) developed a theoretical model for understanding the aging process. This model has two main components described as fluid and crystallized intelligence. Fluid intelligence was defined as the ability to solve novel problems, and involves the ability to be flexible and adaptive when faced with a novel problem-solving situation. In contrast, crystallized intelligence refers to knowledge and skills dependent on the individual's education and experience. Horn and Cattell found that fluid intelligence declined through adulthood while crystallized intelligence tended to stay stable over the life span. Tamkin and Hyer (1984) called this phenomenon the classic aging pattern. They asserted that verbal (crystallized) intelligence remains stable throughout late life while performance (fluid) ability show deficits decades earlier. Therefore, I hypothesize that it is not age that is leading to a decline in functioning, but poor right hemisphere capability is the determining factor. In this relationship, age determining overall functioning capability of the brain, it is important to consider mediating factors. For example, the possibility that the right hemisphere is the mediating variable between age and overall functioning. To reiterate, we need to measure right hemisphere functioning and not just age when we consider an individual's overall functioning abilities.

Although there is little neuroanatomical evidence, some behavioral data suggest that right hemisphere functioning may decline more rapidly than the left. This substantial literature advances the idea that performances mediated by the right hemisphere show a more pronounced decline with age than do those mediated by the left hemisphere. The idea derives from the overall finding that older people are more likely to show impairment on nonverbal than on verbal tests.

Many researchers have proposed that the human brain ages asymmetrically (Meudall & Greenhalgh, 1987). Evidence for this view comes from four diverse sources. First, it has been suggested that elderly individuals are emotionally more reactive than younger individuals. It is often argued that the right hemisphere is involved in the mediation of emotions (Weller & Latimer-Sayer, 1985). Therefore, we can hypothesize that changes in emotional control may be related to right hemisphere aging.

Second, an exaggerated right ear advantage has been found in dichotic listening studies with elderly samples (Weller & Latimer-Sayer, 1985). Auditory information is believed to be analyzed by the contralateral hemisphere, which in this case would be the left hemisphere. This contralateral view is often referred to as the strict model of language processing which sees the body as completely crossed in terms of control (Rastatter & Lawson-Brill, 1987). Our left ear and left side of our body is controlled by our right hemisphere while our right ear and right side of our body is controlled by the left hemisphere. Right ear superiority would reflect the elderly individual's strong left hemisphere control.

Third, the elderly appear to differ from younger individuals in some cognitive abilities, suggesting that processes mediated by the left hemisphere are more effectively preserved in the elderly than those processed by the right hemisphere (Meudall & Greenhalgh, 1987). Finally, differences in expressed hand preference have been noted between young and elderly samples studied cross-sectionally (Weller et al., 1985). The greater incidence of right-handedness in older people could relate to increasing control by the left hemisphere (controlling the right hand) as people age. It is important to note that the greater incidence of right handedness in older people may also be due to cultural rather than to maturational factors.

Goldberg and Costa (1981) describe a right-to-left hemisphere shift which occurs as a function of increased competence. They believe that the right hemisphere plays a critical role in the initial stages of language acquisition, but that the left hemisphere is more useful in later stages of processing. Thus, through routine experience and aging, the human brain begins to rely almost entirely on the left hemisphere for control over cognitive skills.

Similarly, Rastatter and Lawson-Brill (1987) investigated right-hemisphere processing time. It was speculated that, in the course of normal aging, the left hemisphere would inhibit the right hemisphere. Therefore, the right hemisphere would require more time to analyze verbal stimuli. These researchers tested the issue of auditory-verbal processing ability in a healthy geriatric sample. Findings indicated that right-ear (left hemisphere) stimulation yielded significantly faster reaction times to verbal stimuli. The authors suggested that the less proficient linguistic mechanisms in the right hemisphere become more susceptible to the inhibiting influences of the left hemisphere with advanced age.

Goldstein and Shelly (1981) found that as abilities associated with the right hemisphere decline with age, so do left hemisphere abilities. However, the right hemisphere decline appears more drastic. They hypothesized that one hemisphere ages in a different manner from the other. Because the right hemisphere is globally organized and has much white matter facilitating transfer across regions, the right hemisphere hypothesis may be explained based on task complexity rather than deterioration of structures.

Brown and Jaffe (1975) state that cerebral dominance is a continuous process that evolves throughout life. They propose that the right hemisphere is dominant during the prelinguistic period and left hemispheric skills are brought into play as speech develops (post linguistic). This makes intuitive sense when one considers the right hemisphere's role in musical and environmental sounds, visual information, and discrimination of faces; all of which are of paramount importance to the infant. In summary, these researchers state that cerebral dominance is not a state, but a process.

After reviewing the current literature, we propose that the right hemisphere is the mediating variable between age and overall functioning. This current study examined the commonly held belief that an inverse relationship exists between age and cognitive functioning. In other words, as people age their cognitive functioning deteriorates. This study tested the hypothesis that right hemisphere functioning acts as the mediating variable between increasing age and cognitive decline. Measures of right hemisphere functioning will be controlled while the age-cognitive functioning relationship is re-examined to assess whether the inverse relationship remains. Next, measures of left hemisphere functioning will be controlled with the hope that an age-cognitive functioning relationship will emerge. Therefore, we hypothesize that the age effects of overall functioning will be nonexistent when we control for measures of right hemisphere functioning. However, when examining an aging population, it is also important to consider the elements of neuropsychological testing that are unique to the elderly.

Neuropsychological Assessment in the Elderly

A major goal of neuropsychological assessment in the elderly is to differentiate between normal and pathological aging (Price, Fein, & Feinberg, 1980). However, several factors complicate assessment in the elderly. Older individuals tend to have decreased stamina and speed, an increased presence of auditory, visual, and motor problems, and, often, they tend to find the testing situation novel and therefore do not perform to their best ability. In addition, many of the widely used tests do not have valid norms for the elderly (LaRue, 1992).

The elderly tend to tire more quickly than their younger counterparts. Long assessment batteries such as the Halstead-Reitan Neuropsychological Battery are not always efficient for studying an older population. Administration of the complete Halstead Battery may exceed the attention and energy capabilities of most older patients (LaRue, 1992).

Increased sensory impairments accompany aging (LaRue, 1992). It goes without saying that sensory difficulties can greatly change the performance of an individual. The presence of hearing and auditory difficulties are very common among the elderly. Often tests must be modified in order to deal with these handicapping features. However, these adjustments undermine test standardization, further invalidating the norms.

Norms of many current neuropsychological tests are based on the performances of young and middle-aged adults (Price et al., 1980). Most of these norms are not representative of elderly samples. Thus, the elderly are being compared to inappropriate norms and consequently, suggesting deficits that may not be so pronounced.

Cornelius (1984) argued that nonverbal tests are psychometrically more sensitive to the presence of deficit than are verbal measures. Therefore, again, this classic pattern of aging may be the result of poor test selection, artifacts of sampling, and artifacts of statistical analysis. Cornelius also pointed out that nonspecific factors such as unfamiliarity, effort, and speed can determine performance on many of the tests that show age-related decline. Finally, he concluded that young, middle-aged, and elderly adults judge age-sensitive ability tests as less familiar and more difficult and effortful than age-irrelevant ability tests. Therefore, it is suggested that theoretical predictions about the aging process be interpreted cautiously.

LaRue (1992) suggested that clinicians choose their instruments with care. Too often practitioners prefer familiar instruments, rather than ones designed for older adults. She proposes that the clinician perceive the elderly as a distinct group, with unique abilities and needs. Clinicians who follow this advice will more likely put a premium on using measures appropriate to this population.

HYPOTHESES

After examining the results of a number of studies, the following hypotheses were formulated:

1) a) A negative correlation will be found between chronological age and measures of overall intellectual functioning. b) A negative correlation will be found between chronological age and each of the dependent measures.

2) As age increases, measures illustrative of left hemisphere functioning and right hemisphere functioning will decline. Additionally, the relationship between age and measures of right hemisphere functioning is expected to decline more than the relationship between age and measures of left hemisphere functioning.

3) The relationship between age and overall intellectual functioning is mediated by measures of right hemisphere functioning and, if measures of right hemisphere functioning are statistically controlled, no relationship between age and overall intellectual functioning will be found. Or, stated another way, the relationship between age and overall intellectual functioning is not mediated by measures of left hemisphere functioning and if measures of left hemisphere functioning are statistically controlled, a relationship between age and overall intellectual functioning cluster will be found.

METHOD

Participants

A total of 36 older adults (18 men and 18 women) volunteered to participate in the study. Subjects were community-dwelling, older adults who responded to a newspaper advertisement. The subjects live independently and can be considered able elderly. Older adults were split into three groups containing 12 participants each (six men and six women): 55-64 (we called these individuals 'young-old'); 65-74 (we called these individuals 'middle-old'); and 75-84 (we called these individuals 'old-old'). Able elderly with medical or psychological problems which impair activities of daily living, gleaned during the clinical interview, were not included in this study. All participants were right-handed.

The mean age of participants was 69 years old and mean educational level was 14.4 years. A t-test showed no difference between the three groups on sex, vocabulary age-corrected scaled scores, or years of schooling.

Measures

All were administered a battery of neuropsychological tests, each of which fell under one of the following three categories to form the following clusters: Overall intellectual functioning, left hemisphere ability, and right hemisphere ability.

Overall Intellectual Functioning Cluster

a) The Category Test: booklet form of the Halstead-Reitan Neuropsychological Battery. Subjects are administered 208 stimulus figures on letter-size notebooks. At the base of each notebook, a card with the numbers 1 through 4 is mounted so that the subject can point to each answer. The examiner records the answer and informs the subject whether the response was "correct" or "incorrect." Before beginning, the subject is told the test is divided into seven groups and that a single theme runs through each entire group. The subject is asked to try to figure out the theme for each grouping. According to the research literature, the Category Test measures abstract concept formation, learning, and visuospatial skills.

Initially, the Category Test was created to be a visual task administered via projector. For ease in administration and necessary materials, the Category Test was adapted to a clinician-administered booklet form. Both the original and booklet form of the Category Test have been validated on clinical and nonclinical populations, and exhibit virtually identical psychometric data (Fromm-Auch & Yeudall, 1977).

b) Mini Mental State Exam (MMSE): a measure of orientation which is commonly used in hospital settings to glean cognitive functioning. Satisfactory performance on this test necessitates memory ability, orientation, visuospatial skills, written expression, and the ability to follow simple commands.

When subjects were evaluated over a 24-hour period, the test-retest reliabilities were .85 to .99. MMSE scores separated by a period of two years were correlated .38. The MMSE's convergent validity with the Wechsler Adult Intelligence Scale-Revised was .39 for Verbal IQ and .30 for Performance IQ (Mitrushina & Satz, 1991).

c) Wechsler Adult Intelligence Scale-Revised (WAIS-R): is composed of eleven tests, six verbal and five nonverbal. The verbal and nonverbal tests yield a Verbal, Performance, and Full Scale IQ. The reliabilities of these three IQ's are very high, with average coefficients of .97, .93, and .97 for Verbal, Performance, and Full Scale IQ's, respectively. When subjects were evaluated over a 4-6 week period, the test-retest reliabilities were .69 to .95. Furthermore, intercorrelations between the 11 subtests ranged from .21 (Digit Symbol and Object Assembly) to .79 (Information and Vocabulary) (Wechsler, 1981).

d) History (Appendix A): both medical and psychological history, including current medications was gathered.

Left Hemisphere Functioning Cluster

a) Aphasia Screening Test: a subtest of the Halstead-Reitan Neuropsychological Battery. This subtest requires subjects perform a series of tasks: name common objects, spell simple words, identify numbers and letters, read, write, understand spoken language, calculate simple math problems, copy simple shapes, identify body parts, and differentiate between right and left sides of the body.

Factor analysis identified eight content categories (naming, repetition, construction, apraxia, arithmetic, spelling, writing, and reading). Coefficient alphas for each content area ranged from .18 to .94. Additionally, two-factor solutions have consistently been found for the Aphasia Screening Test, with general language abilities and sensorimotor coordination occurring as the main factors, accounting for 56% of the variance (Williams & Shane, 1986).

b) California Verbal Learning Test (CVLT): a learning task which assesses verbal learning and memory. The CVLT measures the immediate, short delay, cued, long delay, and free recall of presented information. We are particularly interested in the number of words learned during the immediate and short delay acquisition period.

Factor analysis of CVLT scores utilizing normal subjects revealed a six-factor solution (general verbal learning, response discrimination, learning strategy, proactive effect, percent primacy and recency recall, and acquisition rate). For our needs, general verbal learning was the only factor of interest. Analyses on the normative sample have cited a coefficient alpha of .74, and split-half reliability as .63. The test-retest reliablility has been found to be .59 (Delis, Kramer, Freedland, & Kaplan, 1988).

c) Wechsler Adult Intelligence Scale-Revised (WAIS-R): is composed of six verbal subtests, namely: Information, comprehension, arithmetic, similarities, digit span, and vocabulary. Only one verbal subtest, arithmetic, is timed.

Right Hemisphere Functioning Cluster

a) Judgment of Line Orientation (JOLO): a perceptual measure which examines the subjects ability to estimate angular relationships between line segments by visually matching angled line pairs to 11 numbered radii forming a semicircle.

Analyses on the normative sample have cited the split-half reliability as .91. The test-retest reliablility has been found to be .90 (Lezak, 1983).

b) Hooper Visual Organization Test (HVOT): a screening instrument designed to measure a person's ability to organize and integrate visual stimuli. The test consists of 30 line drawings depicting simple objects which have been cut into pieces and rearranged in a puzzle-like fashion.

Split-half reliability has been cited as .82 and test-retest reliability of .86. The correlations between HVOT performance with age and intelligence are mild, except in old age; .31 to .50 for intelligence, .04 to .28 for age of younger subjects, and .37 to .69 for age of older subjects. Validity of the HVOT, however, is more variable. Gerson (1974) noted a 19% false negative rate among brain-injured subjects and a 51% false positive rate for normals. Other studies (Boyd, 1981) have not been so optimistic, citing a 85% false negative rate among brain-damaged patients while correctly classifying 97% of control patients.

c) Mini Inventory of Right Brain Injury (MIRBI): Developed in 1989, the MIRBI is a comprehensive test created for the early identification and treatment of neuropsychological disorders associated with right hemisphere brain injury (Pimental & Kingsbury, 1989). Pimental (1987) has developed a classification of right hemisphere syndromes based on specific underlying disorders of processing. It is this theoretical model that forms the basis for the MIRBI and undergirds its 10 subsections. These are: Visual Scanning; Integrity of Gnosis; Integrity of Body Image; Visuoverbal Processing; Visuosymbolic Processing; Integrity of Praxis Associated with Visuomotor Skills; Affective Language; Higher Level Receptive and Expressive Language Skills; Affect; and General Behavior (Pimental & Kingsbury, 1989). The MIRBI should be administered in the order of the subtests just mentioned.

The materials needed for the administration and interpretation of the MIRBI are the Examiner's Manual; the Test Booklet; a pencil and sheet of unlined paper (8-1/2 X 11); a quarter and a caliper. Successful administration of the MIRBI can be achieved by any professional with assessment experience. The MIRBI is intended for use in patients aged 20 to 80 and has an average administration time of 20 to 30 minutes (Pimental and Kingsbury, 1989).

The MIRBI items were standardized via administration to a group of 50 adults with right brain injury, confirmed by computed tomography (C.T.) scan (Pimental & Kingsbury, 1989). The items constituting each MIRBI subsection are intended to be representative of each right hemisphere disorder area. Test-retest reliability was not obtained due to the performance inconsistency in brain injured patients. However, the authors found that the MIRBI had an internal consistency coefficient alpha of .92. Interrater reliability showed fair to good agreement with coefficients ranging from .65 to .87. Three types of validity were investigated. Content validity, construct validity, and concurrent validity of the MIRBI were demonstrated (Pimental & Kingsbury, 1989).

d) Wechsler Adult Intelligence Scale-Revised (WAIS-R): is composed five performance subtests, namely: Digit Symbol, Picture Completion, Block Design, Picture Arrangement, and Object assembly. All performance subtests are timed. Additionally, all the subtests require motor response except the Picture Completion subtest.

Procedure

All participants were tested individually. Able elderly were administered the neuropsychological test battery, as described above, of approximately 2 1/2 - 3 hours in length. All measures employed in this study were administered based on their published standardized procedures.

In exchange for their involvement, the participants received feedback, in regard to their general performance (cognitive and memory) on the measures mentioned previously, at the end of testing and scoring via mail. In addition, participants were informed about the findings of the study following data analysis.

RESULTS

Descriptive Statistics

Measures. The Judgment of Line Orientation (JOLO), California Verbal Learning Test (CVLT), Category Test (CAT), Mini Mental State Exam (MMSE), Hooper Visual Organization Test (HVOT), and Wechsler Adult Intelligence Scale-Revised (WAIS-R) Verbal IQ (VIQ) and Performance IQ (PIQ) were used in testing the hypotheses. Scores for the Aphasia Screening Test and the Mini Inventory of Right Brain Injury indicated ceiling effects and extreme restriction of range and, consequently, were excluded from subsequent analyses. Means and standard deviations for the measures are presented in Table 1.

Intercorrelations. Intercorrelations between the dependent variables are shown in Table 2. The CVLT was moderately correlated with CAT. The HVOT was moderately correlated with JOLO and Performance IQ. Furthermore, CVLT was mildly correlated with MMSE and the JOLO was mildly correlated with Verbal IQ. Performance IQ was mildly correlated with MMSE and Verbal IQ. It appears that measures of right hemisphere functioning correlate with one another, as well as with the left hemisphere measure, Verbal IQ. Additionally, left hemisphere measures correlated with the overall functioning measures.

Factor Analysis. Given the results reported above, dependent variables were factor analyzed in an attempt to reduce potential redundancy among

Table 1

Means and Standard Deviations of Important Dependent Variables (N=36)

Variable	Mean	SD	Min	Max
Age	68.78	8.6	55	83
Education	14.47	2.9	9	20
Mini Mental State Exam	28.78	1.4	24	30
Category Test	50.72	24.1	1	92
Judgment of Line Orientation	23.78	3.8	15	30
Hooper Visual Organization Test	25.15	3.3	15	30
Performance IQ (WAIS-R)	43.14	7.5	29	59
Mini Inv. of Right Brain Injury	41.36	1.4	36	43
California Verbal Learning Test	47.28	12.4	23	75
Verbal IQ (WAIS-R)	68.64	11.1	49	89
Aphasia Screening	31.69	.6	30	32

Note. The means and standard deviations are based on raw scores.

Table 2

Intercorrelations Among the Dependent Variables (N=36)

	2.	3.	4.	5.	6.	7.
1. Category Test	.28	.10	.13	.09	.45**	.14
2. Mini Mental State Exam		.16	.37*	.15	.40*	.24
3. Judgment of Line Orientation			.32	.44**	.07	.39*
4. Performance IQ (WAIS-R)				.51**	.24	.41*
5. Hooper Visual Organization Test					.14	.23
6. California Verbal Learning Test						.31
7. Verbal IQ (WAIS-R)						

* = significant at .05 level

**= significant at .01 level

measures employed in this study and to see if, statistically, the measures combined in the same way as the theoretically driven clusters. A Varimax Rotated Factor Matrix analysis showed two factors (See Table 3). The first factor consisted of Performance IQ, Verbal IQ, the HVOT, and the JOLO. The MMSE, CAT, and CVLT, together comprised the second factor. It is important to note that these factor analysis results are tentative given the large number of factors researched coupled with a small sample size.

Although differing from the factor loadings described in Table 3, right hemisphere (PIQ, HVOT, JOLO), left hemisphere (CVLT, VIQ), and overall functioning (CAT, MMSE) clusters were established based on published research and theoretical findings (Delis, Kramer, Freeland, & Kaplan, 1988; Erickson, Calsyn, & Scheupbach, 1978; Fromm-Auch & Yeudall, 1983; Gerson, 1974; Mitrushina & Satz, 1991; Wechsler, 1981). The clusters based on the literature were subsequently entered into a regression analysis.

Correlations. Before investigating this study's hypotheses, correlations among right hemisphere cluster, left hemisphere cluster, and overall functioning cluster were determined. The right hemisphere cluster was mildly and weakly correlated with the left hemisphere cluster ($r = .39$, $p < .05$) and not correlated with the overall functioning cluster ($r = .27$, $p > .05$). The left hemisphere cluster, however, was modestly correlated with the overall functioning cluster ($r = .48$, $p < .01$).

t-tests. Preliminary t-tests on gender revealed that men scored higher than women on the following measures: Verbal IQ [$t(34) = 3.34$, $p < .005$] ; JOLO [$t(34) = 2.98$, $p < .01$]. Table 4 shows the t-test results for each variable. Further analyses were conducted while controlling for gender which permitted the entire sample to be included.

Table 3

Factor Loadings of the Dependent Variables

Variable	Factor I	Factor II
Mini Mental State Exam	.26	**.66**
Category Test	-.01	**.76**
Hooper Visual Organization Test	**.78**	.01
Performance IQ (WAIS-R)	**.74**	-.02
Judgment of Line Orientation	**.75**	.34
Verbal IQ (WAIS-R)	**.59**	.32
California Verbal Learning Test	.10	**.83**
Eigenvalue	2.63	1.37
% of Variance	37.5	19.6

Note. Factor loadings greater than .50 are in boldface.

* = significant at .05 level

**= significant at .01 level

Table 4

Gender-Based Tests of Mean Differences

Variable	Mean	SD	p
California Verbal Learning Test			
Males	43.4	10.9	.06
Females	51.1	12.8	
Verbal IQ (WAIS-R)			
Males	74.1	10.5	.002*
Females	63.2	8.9	
Performance IQ (WAIS-R)			
Males	44.7	7.7	.21
Females	41.6	7.2	
Category Test			
Males	45.2	21.3	.18
Females	56.2	26.1	
Hooper Visual Organization Test			
Males	25.3	2.8	.75
Females	25.0	3.7	
Judgment of Line Orientation			
Males	25.5	3.8	.005*
Females	22.1	3.1	
Mini Mental State Exam			
Males	28.8	1.3	1.0
Females	28.8	1.6	

Education. A t-test for gender found that these men had significantly higher levels of educational attainment than the women [$t(34) = 3.12$, $p = .005$]. Subjects in this study ranged in level of education from 9 to 20 years. According to Lezak (1983), "Education is positively associated with performance on neuropsychological tests including those that appear to be independent of academic achievement." Consequently, given this sample's range of educational attainment, subsequent analyses controlled for education.

Hypothesis 1a

The first hypothesis stated that a negative correlation will be found between age and the overall functioning cluster. A multiple regression procedure was used to investigate whether scores on the dependent variables were related to age. In predicting the overall functioning cluster, sex and education was entered first into the regression analysis, then left hemisphere cluster measures and finally the right hemisphere cluster measures. Finally, age was entered into the regression analysis. Analyses revealed that as age increases, performance on the overall functioning cluster measures also declined (beta = –.36, R^2 change = .12, $p < .05$).

Hypothesis 1b

Furthermore, the first hypothesis also stated that age will correlate negatively with each of the dependent measures. Congruent age effects were found on the following measures: Performance IQ (beta = –.37, R^2 change = .13, $p < .05$); MMSE (beta = –.34, R^2 change = .10, $p < .05$); and CVLT (beta = –.56, R^2 change = .29, $p < .001$).

Hypothesis 2

The second hypothesis stated that as age increases, measures of the left hemisphere cluster and the right hemisphere cluster decline. However, it was predicted that the relationship between age and right hemisphere cluster decline was expected to be much stronger than that of age and left hemisphere cluster decline. This hypothesis was assessed using a multiple regression analysis. All variables entered into the regression were first transformed into standardized scores. In predicting the left and right hemisphere functioning clusters, education and gender of subject were entered into the regression analysis first followed by age of subject. Age was significantly related to the functioning of both the left (beta = –.50, R^2 change = .23, $p < .005$) and right hemisphere clusters (beta = –.40, R^2 change = .15, $p < .05$).

However, is there a statistically significant difference between age and right hemisphere functioning and age and left hemisphere functioning? To investigate this, a t-test specific for testing differences of dependent correlation's (Cohen & Cohen, 1983) was conducted. A two-tailed t-test indicated that the correlation of age with left hemisphere functioning and the correlation of age with right hemisphere functioning were not significantly different [$t(33) = .84$, $p > .05$].

Hypothesis 3

The third hypothesis stated that the relationship between age and the overall functioning cluster is mediated by measures representative of the right hemisphere cluster functioning and if right hemisphere variables are statistically controlled, no relationship will be found. Put in a negated format, it was hypothesized that the relationship between age and the overall functioning cluster is not mediated by measures of left hemisphere cluster functioning and if left hemisphere variables are statistically controlled, a relationship between age and the overall functioning cluster will be found. In order to test this hypothesis, a multiple regression analysis was conducted. For this analysis, all variables entered into the regression were transformed into standardized scores. In predicting the overall functioning cluster, education and gender of subject were entered into the regression analysis first. Next, the left hemisphere cluster and the right hemisphere cluster scores were entered. Lastly, age of subject was entered into the regression analysis.

The right hemisphere cluster measures did not account for the declines in the overall functioning cluster as a function of age. Contrary to the hypothesis, measures of left hemisphere cluster performance accounted for the decline in the overall functioning cluster as a function of age (beta = .27, R^2 change = .33, $p < .05$).

DISCUSSION

Discussion of these data must necessarily be preceded by a precautionary note. Our sample was not typical of the general population in terms of level of education. Despite high educational attainment, this sample did show the typical cognitive decline with age that is commonly found in older adults. Thus, these data reflect a description of differences between older adults on measures of cognitive functioning that are most directly applicable to individuals with educational backgrounds and experiences similar to the participants used in the present research.

This study explored Klisz's (1978) hypothesis that the right hemisphere accounts for a decline in overall intellectual functioning as a consequence of aging. Specifically, the right hemisphere hypothesis suggested that right hemisphere changes associated with aging are more noticeable than are left hemisphere changes.

The first hypothesis stated that a negative correlation would be found between age and the overall functioning cluster. In other words, as people age, measures associated with overall functioning will decline. For the two measures of overall functioning (Category Test and Mini Mental State Exam), an age-related decline in skill was observed for this cluster.

It was also important to examine the effect of age on each of the dependent measures. For three of the seven measures, an age-related decline in skill was observed. Contrary to the hypothesis, however, four measures did not correlate with age; they were: Category Test, Verbal IQ (WAIS-R), Judgment of Line Orientation, and Hooper Visual Organization Test. The failure to detect age differences on these four measures may reflect a sampling bias.

The hypothesized prediction that scores on the pair of left hemisphere measures and the three right hemisphere measures will decline with increasing age was confirmed. This finding is consistent with much of the research literature that associates aging with an overall decline in cognitive abilities, otherwise known as age-related diffuse cortical atrophy (Elias & Kinsbourne, 1974; Goldstein & Shelly, 1975; Borod & Goodglass, 1980).

Additionally, the relationship between age and right hemisphere cluster decline was expected to be much stronger than that of age and left hemisphere cluster decline. However, we failed to find a greater decline by measures of right hemisphere functioning over that of measures of left hemisphere functioning. Initially it appeared that measures of both the right and left hemisphere clusters declined with age, but the latter exceeded that of the right hemisphere cluster. However, upon further investigation it was found that the correlation between age and right hemisphere functioning and the correlation between age and left hemisphere functioning were not significantly different from one another. Thus, it appears that the right and left hemisphere clusters decline equally with age and any earlier contradictory findings were due to error of measurement.

These findings are contrary to the proposed right hemisphere hypothesis which assumes that the right hemisphere declines with age at a significantly faster rate than the left hemisphere (Klisz, 1978; Tamkin & Hyer, 1984; Meudall & Greenlaugh, 1987; Weller & Latimer-Sayer, 1985; Goldberg & Costa, 1981). They may, however, be inconsistent with other research which states that both hemispheres show equal sensitivity to the effects of aging (Mittenberg, et al. 1989). Here we begin to see that the main tenet of this research, the right hemisphere hypothesis, may not hold up to further scrutiny.

The third hypothesis suggested a mediational model of functioning in older adults. The statistical underpinnings of the theoretically driven clusters which are of primary emphasis in the mediational model need to be examined. The present descriptive statistics suggested a pattern, inconsistent with the theoretically-derived clusters. The present intercorrelations between the dependent variables revealed no statistically reliable relationships between the two left hemisphere measures (Verbal IQ and CVLT), or between the two overall functioning measures (CAT and MMSE). A relationship did emerge between two of the three right hemisphere measures (JOLO and Performance IQ). Furthermore, there was a relationship among overall functioning and left hemisphere functioning measures and among right hemisphere measures and Verbal IQ.

These trends were further clarified by a factor analysis of the dependent measures which identified only two factors. The first consisted of HVOT, Verbal IQ, Performance IQ, and JOLO, which we will refer to as Factor 1. The second factor, which we will refer to as Factor 2, contained MMSE, CVLT, and CAT. We find Factor 2 to be a combination of left hemisphere measures and some overall functioning measures. Factor 1, on the other hand, is more mixed: Three right hemisphere functioning measures loaded on a factor with a measure of left hemisphere functions, namely, Verbal IQ. These findings are discrepant with the theoretical literature in terms of what these tests purport to measure.

This point is further underscored when one considers the correlations between the clusters (right, left, and overall). The right hemisphere cluster was mildly and weakly correlated with the left hemisphere cluster and not significantly correlated with the overall functioning cluster. Furthermore, the left hemisphere cluster was modestly correlated with the overall functioning cluster. It is these clusters that were utilized in the third hypothesis. However, the present findings warrant caution in generalizing with regard to this mediational model. One possibility regarding these discrepant findings is that the left hemisphere measures and overall functioning measures share common processes and actually overlap with one another.

The third hypothesis sought to identify a mediating variable between age and overall functioning in our sample. It was predicted that the right hemisphere functioning cluster would behave as this mediator. Therefore, if right hemisphere variables are statistically controlled, no age and overall functioning negative relationship will be found. Contrary to this hypothesis, however, the right hemisphere functioning cluster did not mediate the age and overall functioning relationship. Instead, and surprisingly, the left hemisphere functioning cluster was found to mediate the age and overall functioning relationship.

It appears that the right hemisphere hypothesis, as it relates to age, was not supported by this study. Measures of left hemisphere functioning were highly correlated with measures of overall functioning. One could speculate that the measures termed overall functioning tasks (Category Test and Mini Mental State Exam) are more accurately categorized as tasks subsumed by the left hemisphere. The Category Test, according to Lezak (1993), is "a learning experiment" that requires learning skills for effective performance. Described this way, the Category Test is very similar to the California Verbal Learning Test (CVLT). In regard to the CVLT, we were interested in the number of words generated over the initial five trials. In other words, the CVLT was also a learning task. Furthermore, we utilized the Booklet form of the Category Test which necessitates the subject respond to the stimuli in a verbal manner.

The Mini Mental State Exam (MMSE) also fell under the overall functioning classification. This test demands a variety of cognitive functions including memory, drawing, orientation, attention, and calculation. Subjects must also respond verbally to the MMSE questions. It appears that the problem of multicollinearity among left hemisphere and overall functioning measures points to the need to redefine the clusters. Therefore, under a different rubric the current findings are not so surprising.

Finally, we must address the exclusion of the Mini Inventory of Right Brain Injury (MIRBI) and the Aphasia Screening Test (AST) from hypothesis analyses. Because both the MIRBI and AST revealed extreme restriction of range and ceiling effect, these tasks appear to have been too easy for this sample of able elderly. Pimental (1989) states that the MIRBI's primary use is in the diagnosis and care of the patient with right hemisphere injury. Therefore, it appears that the MIRBI is not a diagnostically helpful tool in the assessment of healthy, community dwelling adults without any known history of right hemisphere injury. Much of the same rationale can be applied to our subject's performance on the Aphasia Screening Test. Subjects found the AST to be simplistic and most participants scored perfectly on the task. Once again, the AST has its place in the diagnostic world, however it does not appear to discriminate among healthy, community dwelling adults. The AST is, however, useful in the diagnosis of individuals with receptive, expressive, motor, or mathematical difficulties that occur as a result of brain injury.

Methodological Limitations and Future Directions

Representativeness of the Sample

A number of potential sampling biases may limit the generalizability of this study. Firstly, given the racially homogeneous nature of the sample, conclusions based on this study are limited to Caucasian older adults. Secondly, the average level of educational attainment in this study was significantly higher than expected based on the national average. According to Butler and Lewis (1982), only approximately eight percent of older individuals are college educated. In contrast, our study contained 42% college graduates.

In a study which compared older individuals who differed in amount of education and socioeconomic status, Albert and Moss (1988) found that subjects who were more highly educated performed better on a variety of memory tasks. Therefore it appears that performance on a memory measure depends strongly on factors such as educational level and socioeconomic status. This may explain why our sample performed so well on the memory tasks included in this research assessment, namely the California Verbal Learning Test.

Furthermore, if people are more highly educated and, in turn, gain employment in jobs that lead to higher socioeconomic status, they are less likely to be engaged in blue collar work. It is fair to say that blue collar labor is often hands-on, manual labor which exercises the right, visuospatial hemisphere. Individuals in our sample may not have ever engaged in the amount of manual labor that is more common to less educated persons.

Moreover, if people were not used to engaging in visuospatial tasks as younger adults, they may, as older individuals, be more apt to spend time in activities consonant with their prior white-collar work history. For example, they may involve themselves with reading and writing, both of which exercise the left hemisphere.

Thirdly, it is questionable whether, and to what extent, results based on this sample will generalize to other older adults. In other words, is our sample representative of the general older adult public? The current study participants were subjects who had served in the MSU Psychological Clinic's Mood and Memory Project. Approximately 100 of these subjects were recontacted by phone and invited to take part in this new study. They were informed that, in return for their volunteered time, they would be given written feedback in regard to their general cognitive and memory functioning. As subjects agreed to volunteer, it was necessary for the research investigator to contact individuals of a particular gender and age in order to fill the criteria of an age- and sex-stratified sample.

It may be that older adults in the community who were experiencing more decline than their peers were too self-conscious about their cognitive difficulties to participate in this study. That is, older subjects in this study may represent an especially healthy subset of community dwelling older adults. In two recent Mood and Memory studies investigating test performance in the original sample of able elderly participants, it was found that the mean score was 27 out of a possible 30 total points (Gannon, 1994; Merwin, Denburg, & Abeles, 1993). However, the current research project found that, on average, participants scored 29 out of a total of 30 points. Therefore, we can say with greater certainty that our participants appear healthier than the larger sample from which they were drawn.

Finally, the present study is cross-sectional in design and conclusions drawn from this research may reflect cohort differences instead of aging per se. In addition, cross-sectional methodologies limit causal interpretations.

Future Directions

The aim of this study was to compare measures of right hemisphere functioning, left hemisphere functioning, and overall functioning across the older adult age span. Future studies on this topic ought to include a greater range of functioning within the older adult sample including more variation in educational background, in addition to a larger sample size. Furthermore, future research in this area should carefully consider the categorization of measures in an effort to avoid redundancy and multicollinearity.

Summary

It has been suggested that the right hemisphere ages more rapidly than the left. A right hemisphere hypothesis (Klisz, 1978) has been put forth to account for this decline in cognitive abilties as a result of aging. An age- and sex-stratified sample ($N = 36$, ages 55-84) of able-elderly persons were individually administered a battery of neuropsychological tests, each of which represented either overall functioning, right hemisphere functioning, or left hemisphere functioning. A modest decline of overall functioning abilities were found with advancing age (beta = –.36, R^2change = .12, $p \leq .05$). Furthermore, results supported the conclusion that among older individuals, measurable neuropsychological changes occur in both right (beta = –.40, R^2change = .15, $p \leq .05$) and left (beta = –.50, R^2change = .23, $p \leq .005$) hemisphere abilities. Finally, in an effort to investigate general decline as a consequence of aging, it was hypothesized that measures of right hemisphere

functioning would act as a mediator and account for the decline in overall functioning abilities. Contrary to expectations, only measures of left hemisphere functioning significantly accounted for this decline (beta = .27, $\underline{R}^2$change = .33, $p \leq .05$). Two of the administered measures, namely the Aphasia Screening Test and the Mini Inventory of Right Brain Injury, did not discriminate in this research population. Methodological concerns and future directions were discussed.

APPENDICES

APPENDIX A:

History Questionnaire:

Before we begin testing, I have some questions to ask you.

Subject number________

Date__________________

DOB____________ Age_______ Gender__________

Education_____________

Handedness_______

Current Occupation or Volunteer work___________________________

____

Developmental History

Number of siblings____

____

Health problems of parents and siblings__________________________

____

____

Mother's pregnancy____

____

Age at pregnancy_____________

Birth complications or injuries (forceps, anoxia, use of ICU)__________

____

Developmental milestones (e.g., age of walking, talking)_____________

____

Significant diseases (high fever, meningitis)______________________

____

Injuries____

____

School/Educational History

Highest grade attained____

Age terminated school____

Reason for leaving school______________________________________

____

Grades____

- Grade school____
- High school____
- College____

Special Training____

____

Best/worst subject____

Learning Disabilities____

____

Adult Medical History
Diseases______________________________
____
Hypertension______________________________
____
Stroke______________________________
____
Dementia______________________________
____
Hospitalizations______________________________
____
____
Surgeries______________________________
____
____
Incidents involving loss of consciousness______________________________
____
Head injuries______________________________
____
Headaches______________________________
____
Injuries to extremities (peripheral nerve damage)______________________________
____
Numbness or tingling______________________________
____
Impairments in motor functioning______________________________
____
____
Impairments/Correction in vision______________________________
____
Double vision______________________
Blurring______________________
Blindness______________________

Psychiatric History
Treatment for emotional problems______________________________
____
____
Hospitalizations______________________________
____
Medications______________________________
____
____
ECT history______________________________
____

<u>Alcohol/Drug History</u>

Average alcohol intake____

____

How long________________________

Treatment for alcohol problems___________________________________

____

Drugs taken____

____

How long________________________

Treatment for drug problems_____________________________________

____

____

APPENDIX B:
Medications Questionnaire

Can you list all the medications you have taken in the last week:

	Name of Medication	Dosage	Frequency
1.	____________	____	________
2.	____________	____	________
3.	____________	____	________
4.	____________	____	________
5.	____________	____	________
6.	____________	____	________
7.	____________	____	________
8.	____________	____	________
9.	____________	____	________
10.	____________	____	________

Appendix C:
Consent Form:

NEUROPSYCHOLOGICAL FUNCTIONING OF OLDER ADULTS

Thank you for volunteering for testing. Your contribution to this study will be invaluable to us. In this project, we are trying to better understand thinking and reasoning in older adults. We are also trying to improve our current neuropsychological tests, and the results that you provide will help us do that.

In this study you will do many different things. Some of the tests may seem easy to you while others appear harder. The exam will take approximately two and a half hours.

All information that you provide us is strictly confidential. After your exam, your test results will be filed under a code, without using your name or any biographical information. These records will be maintained in a secured file. We will provide you with feedback on testing, in regard to you general performance (thinking and reasoning) as compared to others your age, at the end of testing via mail.

Participation in this study is voluntary, and you are free to withdraw from the project at any time. In addition, you may refuse to do a particular task, and we will continue with the next one. Certainly, the more you are able to complete, the more your participation will assist us in our research.

At this time, please ask any questions you have. Then, indicate your understanding and willingness to participate by signing this form in the space provided below. You will receive a copy of this agreement. If you have any questions in the future, call 517-355-9564 and ask for Natalie Denburg.

____
Signature

____
Date

Appendix D:
Inventory of Scores:

sex	age	educ	mmse	jolo	cvlt	categ.	hvot	VIQ	PIQ
M	71	12	30	24	50	63	25.5	131	103
M	72	20	30	27	48	26	25.0	150	102
M	78	14	28	19	37	56	20.0	113	120
F	61	12	29	25	75	22	28.0	105	113
M	75	16	28	24	27	44	24.0	122	120
F	82	14	28	25	23	72	26.0	109	121
F	56	16	30	23	73	26	30.0	133	131
F	74	15	28	26	53	26	18.5	104	105
F	74	14	30	15	48	62	24.5	108	114
F	56	18	30	21	63	17	24.5	109	100
F	73	15	30	20	49	33	27.0	108	130
M	75	16	30	30	53	56	27.0	125	128
F	75	12	28	25	42	68	27.0	98	125
F	78	12	24	17	49	82	21.0	127	103
F	56	14	29	22	69	81	26.5	110	115
M	75	16	28	29	38	123	27.0	113	133
M	58	13	30	27	47	62	26.5	127	111
M	75	16	27	26	32	75	26.5	118	125
F	78	12	30	19	42	95	26.0	111	121
F	55	10	30	25	47	31	25.5	98	104
F	81	10	30	23	40	26	25.0	113	119
M	56	16	29	27	43	44	26.5	115	110
M	60	18	30	27	60	8	28.0	133	122
M	64	16	28	27	53	62	21.0	120	103
M	69	20	30	29	58	33	30.0	136	117
F	75	11	28	23	40	30	26.5	121	126
F	59	12	29	24	54	29	29.0	104	99
F	69	12	27	23	56	14	24.5	117	110
F	73	12	30	18	49	54	14.5	110	101
M	67	12	27	26	24	80	28.0	94	105
M	65	19	28	28	44	39	25.0	106	92
M	68	20	30	20	41	67	20.0	109	106
M	83	9	26	16	27	57	25.0	103	121
F	74	15	28	23	48	20	25.5	116	115
M	59	16	30	24	55	43	23.0	130	119
M	57	16	29	29	45	72	28.0	119	130

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