HAPTIC VISUAL SENSORY INTEGRATION: A COMPARISON BETWEEN NORMAL, SCHIZOPHRENIC, AND BRAIN DAMAGED GROUPS

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Ann Wigodsky, M.S.
Denton, Texas
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Neuropsychological tests have been used in differentially diagnosing schizophrenic and brain damaged populations. Research indicated some subgroups of schizophrenia exhibit certain symptoms of brain damage; and that schizophrenia involves difficulty in sensory integration. The Haptic Visual Discrimination Test (HVDT) designed to test tactile-visual integration, Bender Gestalt, and Information and Digit Symbol subtests of the WAIS were used to test performance abilities of forty schizophrenic subjects, forty subjects medically diagnosed as brain damaged (10 right hemisphere, 10 left hemisphere, and 20 diffuse), and normals as defined by the standardized age norm scores.

Results between normal and schizophrenic groups were significant for the Information subtest ($P < .01$), Digit Symbol subtest ($P < .001$) and the right and left hand HDVT total scores ($P < .05$, $P < .01$) respectively. Multiple discriminant analyses using the Bender Gestalt, Information, and Digit Symbol subtests, and HDVT total scores showed statistically significant differences between schizophrenic

and brain damaged groups as a whole (P = .003); schizophrenics and acute and chronic brain damaged groups (P = .0001), schizophrenic, right hemisphere, left hemisphere, and diffuse brain damaged groups (P = .00001); schizophrenics showing right hemisphere lateralized dysfunction, right hemisphere, left hemisphere, and diffuse brain damaged groups (P = .0001); and schizophrenics showing left hemisphere lateralized dysfunction, right hemisphere, left hemisphere, and diffuse brain damaged groups (P = .0004).

Results indicated tests of sensory integration were statistically significant in discriminating between normals, schizophrenic and brain damaged groups. A subgroup of schizophrenics emerged that showed lateralized sensory integration deficits with a higher incidence of right rather than left hemisphere dysfunction. Lateralized brain damage was frequently misclassified as schizophrenic and schizophrenics showing left hemisphere sensory integration deficits were misclassified as brain damaged. A subgroup of schizophrenic subjects with left frontal and right parietal occipital dysfunction was identified.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

HAPTIC VISUAL SENSORY INTEGRATION: A COMPARISON BETWEEN NORMAL , SCHIZOPHRENIC, AND BRAIN DAMAGED GROUPS

Frequently, psychologists have been asked to differentially diagnose brain damage, a nonspecific structural brain lesion, versus schizophrenia a "functional psychosis." The prevalent method used for differential diagnosis has been the use of test scores to identify these groups as statistically separate categories. Current research in the area of diagnosis and treatment address the issues of whether differential diagnosis is essential and if these two groups differ significantly in behavioral (skill) assets and deficits (Filskov & Boll, 1980).

Neuropsychological tests which assess brain-behavior relationships have become more popular as screening devices in psychiatric settings. However, the literature reports conflicting data concerning the ability of neuropsychological tests to discriminate between "functional psychosis" and brain damage. In addition, the literature suggests that a large percentage of patients labeled schizophrenic, especially chronic schizophrenic, may also have brain impairment, thus creating difficulty in establishing a differential diagnosis between these two groups (Barachas et al., 1977). A series of studies by Silverman (1968) and Buchsbaum and Silverman (1968) investigated the possibility that schizophrenics process sensory information differently than normal individuals. They theorized that alterations in the sensory integration process may ultimately produce schizophrenic symptoms.

Some neuropsychological tests attempt to assess the process of sensory integration. Deficits and assets in sensory integration result in a pattern of skills that will either be beneficial or detrimental to the individual. Consequently, the use of sensory integration tests to assess similarities and/or differences between brain lesion patients and schizophrenics may be of assistance not only in differential diagnosis but also in the development of treatment plans, especially when skill assets and deficits can be identified.

Another issue has been one of the inadequacy of diagnosis. Goldstein (1978) discussed the term organicity or brain damage, as being too broad a category for research. The type and degree of behavior as a result of brain damage depends on the extent, location and type of lesion. Many researchers have begun to classify their brain lesioned groups according to location and type of lesion such as left hemisphere, right hemisphere, or diffuse damage (Schreiver et al., 1976). The term schizophrenia also has been reported as being too loosely defined (Malec, 1978). Several researchers have used the process-reactive dimension or acute versus chronic to distinguish subtypes of schizophrenia (Davis et al., 1972; O'Keefe & De Wolfe, 1978; Parsons & Klein, 1979). Malec

(1978) found only 38% of the studies he reviewed using procedures beyond the conventional neurological exam, such as CT scan or EEG, in validating their brain damaged sample. Only 24% of the studies reviewed used some type of standardized assessment of psychopathology or consensual, independent professional agreement to classify their schizophrenic sample. Malec concluded that the validity of the diagnosis used to differentiate the brain damaged and schizophrenic groups has been questionable.

The main issues appear to be a) difficulty of differential diagnosis between a brain lesion and a functional psychosis; b) the inadequacy of diagnostic definitions for research between these two groups; and c) the use of neuropsychological tests to assess the differences between and within these two groups in the area of sensory integration, including recommendations for treatment; d) possible involvement of brain damage in some subgroups of schziophrenia.

Considering the issues that were prevalent, the first research question in this study was whether schizophrenics, brain lesioned patients, and normals performed differently on neuropsychological tests in the area of complex sensory integration. A second research question was whether or not the results of the neuropsychological testing would indicate patterns of skill deficits exhibited by schizophrenic subtypes and how these patterns compared to the patterns exhibited by the brain lesioned subtype groups. The investigation additionally attempted to determine whether neuropsychological test results in the area of sensory integration could be used to discriminate apparently non-organic schizophrenics and schizophrenics who show symptoms of brain damage. A further consideration was to establish a pattern of skill deficits in sensory integration, which has implication for treatment plans for patients diagnosed schizophrenic.

Heaton et al. (1978) reviewed 94 studies concerned with the ability of neuropsychological tests to discriminate between cerebral dysfunction and nonorganic psychiatric disorders and reported that most studies used relatively diffuse and chronic organic patient populations, while the psychiatric groups varied widely in different diagnostic classifications. They concluded that all psychiatric groups except chronic or process schizophrenics performed better than organics on neuropsychological tests and that most studies attempting to discriminate between chronic schizophrenics and organic patients obtained only chance level results.

Heaton et al. (1978) found that hit rates, which reflect prediction accuracy of diagnosis in correctly classifying subjects, ranged from as low as 55% to as high as 85%. It appeared that when chronic schizophrenics were included in the psychiatric groups tested the hit rate decreased markedly in discriminating between organic and psychiatric populations. These researchers concluded that one reason neuropsychological tests could not discriminate between chronic schizophrenics and organics was that a significant proportion of chronic schizophrenics were also organic.

Goldstein (1978) after reviewing the literature on cognitive and perceptual differences between schizophrenics and organics, concluded that it was not worthwhile to direct research toward binary classification into brain damaged and schizophrenic groups. He suggested that future research should attempt to seek distinctions and similarities among behavioral and neurological variables between patients called brain damaged and those called schizophrenic. He summarized three methodological problems in his review which were persistent throughout the literature: diagnostic accuracy, inadequate sampling, and difficulty in interpretation of the subjects performance.

A multitude of tests have been used in attempting to diagnostically differentiate among schizophrenics and brain damaged patients (e.g., Memory for Designs (MFD), Benton Vistual Retention Test (BVRT), Trail Making Test (TMT), the Bender Gestalt either with or without Background Interference Procedure, Wechsler Adult Intelligence Scale (WAIS), Halstead Reitan Battery (HRB), Critical Flicker Fusion, Goldstein Scheerer Cube Test, Tactual Performance Test (TPT), and the Luria Nebraska Neuropsychological Battery). Testing in the past has involved various psychiatric groups, but those studies involving only acute and chronic schizophrenics are reviewed.

Many studies have used intelligence tests either alone or in combination with other tests. Watson (1965a, 1965b) used the WAIS and found that schizophrenic and organic patients were not significantly different in terms of intertest scatter or level of functioning. He did find that the Digit Span subtest scores were significantly higher for schizophrenics than for his brain damaged group. No significant difference was found on the WAIS Full Scale IQ of 13 reactive schizophrenics and 13 organics by Davis et al. (1972).

In cross validation, schizophrenics showed less impairment, relative to their own mean level of performance across all subscales, on the Digit Symbol. De Wolfe et al. (1971) compared WAIS deficit scores of 50 chronic schizophrenics and 50 organics and found that schizophrenics had poorer performance on the Digit Symbol than did organics and hypothesized this resulted from differing intellectual deficit patterns in chronic schizophrenics and brain damaged patients. Goldstein and Halperin (1977) compared chronic schizophrenics with and without brain disorders. They found by using the WAIS and Halstead Neuropsychological Battery scores in a discriminant function, they could identify long term versus short term hospitalized patients. Although the "hit rate" for discriminating between neurologically normal and neurologically abnormal schizophrenics exceeded chance levels, it was not considered by Goldstein and Halperin to be impressive. Chelune et al. (1979) evaluated three specifically defined groups: schizophrenics, acute brain damage patients, and chronic diffuse brain damage patients. Eleven WAIS subtests and 12 HRB subtests were administered. Analysis showed that the schizophrenics mean performance levels were higher on both batteries than those of the two brain damaged groups. However, in further analysis of patterns of performances, very few differences were found among the three groups when the level of performance was controlled. Other studies showed mixed results in attempting to make differential diagnoses between schizophrenic and brain damaged populations on the basis of intelligence tests (Fredricks & Finkel, 1978; Small et al., 1972).

In summary, intelligence tests have been shown to have some success in discriminating between psychiatric and organic disorders. However, when schizophrenic populations were used in the samples, an overlap between the two groups emerged and intelligence tests could not reliably discriminate between psychiatric and organic disorders. Most studies have found that schizophrenics could be discriminated from normals but that they performed in a similar way as brain damaged populations when using either level or pattern analysis. One conclusion drawn was that on some level, schizophrenic patients have CNS dysfunction or some type of brain damage although the etiology is unkown.

Many tests with speed and accuracy as the dependent variable have been used in attempts to differentiate between schizophrenics and brain damaged populations (e.g., the Bender Gestalt, BVRT, TMT, and Finger Tapping Tests). Fuller and Fredricks (1976) compared groups of organics, psychotics and personality disorders on several measures of the Minnesota Percepto Diagnostic Test (MPD) and results indicated that organics performed worse than the other two groups which did not differ from each other. However, Watson and Uecker (1966) found no significant differences between the MPD scores of organics, paranoid schizophrenics, chronic schizophrenics and lobotomized chronic schizophrenics. L'Abate et al. (1962) found that scores on the TMT, BVRT, and Kahn Test of Symbol Arrangement failed to differentiate chronic schizophrenics from organic patients. Watson et al. (1969) found no differences between chronic schizophrenics and organics on the TMT, Hand Dynometer, Critical Flicker Fusion and Light Intensity Matching Test. Embree (1967) using the Embree/Butler scoring system was able to significantly differentiate between organic and psychiatric groups using the Bender Gestalt. Studies by Rosencrans and Schaffer (1969) and Cooper and Barnes (1966) found that psychiatric groups did better than organic groups on the Bender Gestalt.

A multitude of studies have used the Halstead Reitan Battery, or at least parts of it, to discriminate between schizophrenics and organics. De Wolfe et al., (1971); Fields and Fullerton (1975); Small et al., (1972); and Stack and Phillips (1970) found that these tests could significantly discriminate between these two populations; whereas Klonoff et al., (1970); Lacks et al., (1970); and Watson, (1968) found that they would not. In a psychiatric setting, Watson (1968) found no significant differences using the HRB among short term hospitalized or long term hospitalized organics and schizophrenics; however, Levine and Feirstein (1972) made essentially the same comparison but found significant differences between these groups. Furthermore the Finger Tapping Measure, (a simple test of motor speed) and a sub-test of the HRB was one of the more successful tests in discriminating between brain damage and schizophrenic populations (Levin & Feirstein, 1972; Stack & Phillips, 1970).

One of the few studies using the HRB that showed some positive results in the correct indentification of schizophrenics versus organics was that of Golden (1977). His groups were left brain damaged, diffuse brain damaged, right brain damaged, and psychiatric patients. Significant differences among the four groups was demonstrated on 29 of 38 measures. When all 38 measures were used to differentiate brain damaged and psychiatric groups, Golden (1977) found that 100% of the psychiatric group and 94.2% of the brain damaged group could be correctly identified. According to Filskov and Boll (1981), a possible explanation for Golden's findings may be the result of the exclusion of individuals from the study: a) who had acute side effects of medication, and b) who may have spent more than one year in a psychiatric hospital.

The Luria Nebraska Neuropsychological Battery (LNB) has been found to be useful in discriminating between brain damaged schizophrenic and normal subjects (Golden et al., 1978; Moses & Golden, 1979; Purisch et al., 1978). Purisch et al. (1978) found that a discriminant analysis using 60 of the 282 items on the LNB demonstrated 100% diagnostic accuracy between 100 schizophrenic and brain damaged patients. A discriminant analysis using 14 summary measures showed 88% diagnostic accuracy. Of these summary measures, only rhythm, impressive speech, memory and intelligence failed to discriminate between the groups. Schizophrenics performed better than organics on the motor, tactile, visual, left hemisphere and right hemisphere indicies. Their study reported the accuracy of the battery even remained high when chronic schizophrenics were included.

In their study, Hammeke et al. (1978) found that the LNB could distinguish between normals and neurological patients. Golden (1982) discussed the results of the Purisch et al. (1978) and Hammeke et al. (1978) studies. He concluded that schizophrenic patients performed at an intermediate level between normal controls and brain injured patients. After his own evaluation of individual patient results generated by these studies, Golden found: a) 50% of the schizophrenics showed profiles classifying them as brain injured; b) 33% were classified as normal; and c) 12% were marginal between brain injured and normal. He concluded that overall the results from these studies were mixed and some of the schizophrenics were indeed showing signs of brain injury. Overall the review of the research using the Luria Nebraska Neuropsychological Battery revealed that although neurological and schizophrenic patients performed differently, schizophrenic patients also performed differently than normal controls.

The literature suggests an emergence of a new trend in research in the last few years. The new research focus has been aimed at understanding more narrowly defined neurological process (skills) in order to derive more global knowledge of brain behavior relationships. Goldstein (1978) discussed the problems associated with assessing the clinical utility of neuropsychological tests like the Halstead Reitan Battery. He concluded:

> Perhaps the major conceptual "breakthrough" was a discovery of the nonproductivity of approaches directed toward binary classification into schizophrenic and brain damaged groups. There appears to be a growing concensus that schizophrenia is based on some kind of CNS difference, although its specific nature is far from understood. Thus, there has been a shift in emphasis from diagnostic classification to studies of those underlying processes

> that produce the kinds of dysfunction seen in schizophrenic patients (p. 176).

Recent research investigations have revealed many discrepancies associated with differentially diagnosing schizophrenics from organics. While utilizing neuropsychological tests for diagnostic purposes has been beneficial, the utilization of such tests for treatment planning has been equally important (Golden, 1978). In their introduction in the Handbook of Clinical Neuropsychology (1980), Filskov and Boll state:

> The first (motive for investigating neuropsychological intactness of psychiatric groups) is that a comparison of psychiatric and organic patients offers an opportunity to establish the type and pattern of test deficits that best discriminate between these disorders. These comparisons provide clinicians with an effective means of dealing with the most common reasons for requesting a psychological consultation, namely, differential diagnosis. Beyond that practical purpose, this research may pose the more basic question of the etiological role of organic factors in the development of psychiatric disorders. Equally important is the description of organic and psychiatric groups in terms of their salient features and performance on standardized tests. The use of these tests allow for a definition of these groups in terms of specific deficits and assets

and thereby may provide behavioral objectives for treatment (p. 17).

Luria (1966, 1973) discussed a general conceptual approach to interpreting skill deficits from neuropsychological test performances. He conceptualized each part of the brain as being involved in one of three basic functions. The first is the regulation of arousal level and maintenance. The second is the recognition, integration and analysis of sensory information from both the internal and external environment. The third function involves planning, executing and verifying behavior. Luria feels all behavior involves the interaction of these basic functions, and that each area in the brain has a specific role in each behavior. The role function of any area in the brain depends upon the behavior that must be performed, and Luria discussed functional systems for each behavior. According to Luria, each functional system involves more than one cell or cell assembly, but there is a finite number of elements in each system. Functional systems are like chains in that each cell is involved somehow in the mediation of the behavior for which that system is responsible. Elements may be involved in more than one system and more than one functional system may be involved in behavior. For example, an arithmetic problem may be learned by rote memory or by a more analytic process, although the outcome may be the same, it is derived using two different functional systems. Luria's view of brain-behavior relationships underlying neuropsychological test performances is that any task/test assessing higher cortical function is mediated by a functional system or systems.

In related research, many authors have questioned whether or not schizophrenia has some underlying cerebral dysfunction. Mirsky (1969) reported certain EEG abnormalities associated with different phases of schizophrenia. Carr (1980) tested schizophrenics on a task requiring discrimination of tactual size and shape, and found that schizophrenics performed worse with an intermanual task than a same hand task and worse than controls on both tasks. Dimond et al. (1979) found that schizophrenics had more left hand object naming errors on a tactual recognition task. Johnstone et al. (1976) found a significant association between cerebral atrophy and cognitive impairment in schizophrenics using the CAT scan.

Some research investigated the question of whether schizophrenia is a lateral brain dysfunction. Gur (1978) found that schizophrenic patients had left visual field advantages in both syllable recognition and dot localization. Gur attributes a generalized right sidedness deficit to a left hemisphere dysfunction in schizophrenics (Gur, 1977, 1979). Gruzelier and Hammond (1976) found right ear (left hemisphere) superiority in schizophrenics for high tones but which was inconsistent and decreased with improvement in psychotic symptoms and interpreted this as left hemisphere dysfunction. Newlin et al. (1981) in their review of hemisphere asymmetries in schizophrenics concluded:

> However, in the cases where clear lateralized differences were found, the results were suggestive of left hemisphere dysfunction or hyperarousal, while there were no results clearly suggestive or right hemisphere dysfunction (p. 568).

Much of the previously reviewed literature had dealt with cognitive and motor functions, but not necessarily with higher coritcal functions or integration processes. Complex sensory integration (i.e., visual, tactile and kinesthetic) functions are higher cortical functions and some behavior seen in schizophrenics suggests this area is an important dimension in understanding schizophrenia (Luria, 1973).

Research conducted by Boll, 1974; Boll and Reitan, 1972; Reitan, 1974 in the area of neuropsychology has concluded that evaluations of tactile sensitivty contribute important diagnostic information concerning brain-behavior relationships. Some of the tests used include: Tactile Performance Test, Tactile Form Recognition, Tactile Finger Recognition, and Fingertip Number Writing Perception Test. McCarron and Dial (1975, 1976) have attempted to further this area by combining a non-verbal form of sterognostic testing procedure, where the subject is requested to match tactually perceived objects with a series of visually presented pictures to assess higher cortical functions in the area of sensory integration.

The Haptic Visual Discrimination Test (HVDT) designed by McCarron and Dial (1979) has been shown to be very sensitive in its abilities to reflect the behavioral functioning of the parietal occipital lobes at a higher cortical level. It was

> specifically designed to require skills in tactile sensitivity, spatial synthesis and the ability to integrate the elements of an object in a unified whole. When problems are encountered in synthesizing such information, the underlying neurological dysfunction which appears to be common to both tactual and visual information processing is a "disturbance in the ability to integrate single stimuli into simultaneous structures or groups" (Luria, 1966), (McCarron & Dial, 1979, p. 11).

Luria (1966) found that the parietal and occipital areas of the cortex have several major functions, three of which are: processing cognitive information, processing cutaneo-kinesthetic data, and integrating visual and tactile information. Luria has stressed the importance of these areas as mediating centers of higher intellectual processes. McCarron and Horn (1979) found significant correlations between the Haptic Visual Discrimination Test (HVDT), Bender Gestalt and WISC-R. Significant correlation coefficients were found between the HVDT and each WISC-R subtest. McCarron and Horn found a negative correlation between the Bender Gestalt and HDVT, which indicated a positive relationship between errors made on the Bender Gestalt using the Koppitz scoring system and scores on the HVDT. These results tended to support the relationship between the HVDT scores and higher cortical functioning.

The HVDT can be administered to both hands examining left and right hemisphere functioning in the parietal-occipital area of the cortex. Since the HVDT examines lateralized Haptic sensory integration functions, test scores from the schizophrenic population can be compared to both lateralized and diffuse brain lesion populations. The HVDT has been standardized for both normals and neuropsychologically disabled. The HVDT contains 4 subtests: shape, size texture, and spatial configuration. A factor analysis performed by McCarron and Dial (1979) showed that size and texture subtests loaded heavily for one factor while the shape and spatial configuration subtests loaded heavily on a second factor. The authors designated these factors as being a) comparative analysis (size and texture); and b) spatial integration (shape and configuration). Furthermore they believed that the comparative analytic function was processed in the left and right hemispheres in the parietal-occipital lobes whereas the spatial integration function was processed only in the right hemisphere parietal occiptal lobes

Research findings are at best, mixed in their efforts to differentially diagnose schizophrenia and brain damage as traditionally measured by neuropsychological tests. Goldstein (1978) concluded that detection of major behavioral differences among various subtypes of schizophrenia and brain damage could be used in an attempt to resolve the differential diagnosis dilemma. Chelune (1979) concluded that the question may no longer be whether cerebral dysfunction is present or absent in schizophrenia, but rather is a question of degree: that is; how much of the observed patients' behavior is a result of psychiatric versus neurologic factors.

Therefore, the purpose of the present study was to: a) examine skill assets and deficits between schizophrenic and brain lesioned (damaged) populations in the area of complex sensory integration; b) to assess whether the HVDT could be used to make differential diagnoses between schizophrenic and brain damaged populations; and c) to determine whether or not there was a difference in performance between normals and schizophrenics in the area of sensory integration. Four tests were adminstered: the Haptic Visual Discrimination Test for both hands, the Bender Gestalt, the Information and Digit Symbol subtest from the Wechsler Adult Intelligence Scale. The Information subtest was included as a general measure of ability. Since the Bender Gestalt and Digit Symbol subtest traditionally have been used as indices of gross motor impairment, they have been included as additional measures of organicity. Scores from the four tests were compared between 40 schizophrenic patients and 40 brain lesioned or damaged patients (10 right hemisphere damaged, 10 left hemisphere damaged and 20 diffuse damaged patients). Scores between the schizophrenic group and the standardized scores for normals were compared.

It was hypothesized that a) the Bender Gestalt, Information subtest, Digit Symbol subtest and the HVDT would dicriminate between normal, schizophrenic and brain damaged groups, b) the schizophrenic group's ability to integrate sensory (tactual-visual) information would be less than normals ability, yet better than the brain damaged groups ability to integrate sensory information, c) the brain damaged group would show more pathology than the schizophrenic group in the right and left hemispheres, d) the tests would dicriminate between acute and chronic schizophrenics and acute and chronic damaged subjects with acute schizophrenics and acute brain damaged subjects having more ability to integrate sensory information than chronic schizophrenics and chronic brain damaged subjects; e) the performance by the schizophrenic population would show a laterlized sensory integration deficit, f) the ability of the schizophrenic population showing a lateralized sensory integration deficit would be similar to the ability of one of the brain damaged subgroups (right hemisphere, left hemisphere, and diffuse).

Method

Subjects

Forty subjects were selected with a primary diagnosis of schizophrenia, according to the DSM III criteria. Each subject was an inpatient from an acute mental diagnostic and evaluation facility who had no evidence of past or present brain injury, head trauma, alcoholism or ECT. All were between the ages of 18 and 45 with a 0 to 45 year history of chronicity, which was evaluated from first documented hospitalization. Schizophrenics were combined upon the basis of years since first hospitalization i.e., "acute" (less than 2 years) versus "chronic" (more than 2 years). Each subject diagnosed schizophrenic had presently been on medication less than three days. The mean age of the group was 27.3 years (S.D. = 8.3). Twenty eight were male and 12 female. Twenty nine were right handed and 11 left handed. The mean education level was 12.3 years (S. D. = 1.1).

The brain damaged group consisted of 40 anonymous file cases referred for neuropsychological evaluation from various rehabilitation, legal and private sources. The cases were submitted by three psychologists from the state of Texas. All were between the ages of 17 and 45 with a medical diagnosis of brain damage with a 2 month to 21 year history of chronicity, defined as date of evaluation minus date of onset of injury. For this study brain damage was bined as "acute" (less than 6 months) versus "chronic" (more than 6 months). All diagnoses were made by either clinical, surgical, or radiographic evidence. Of the 40 subjects: 20 were diagnosed as having diffuse damage, 10 as having left hemisphere damage and 10 as having right hemisphere damage. The causes of brain damage were: 23 from closed head injuries from motor vehicle accidents; 6 from aneurysms; 6 from gun shot wounds; one from a stroke; two from falls; and 2 from penetrating fragments. The mean age of the group was 27.2 years (S.D. = 8.7). Thirty two were male and eight female. Thirty six were right handed and four left handed. The mean education level was 11.6 years (S.D. = 1.6).

The controls (normals) were defined by the standardized age norm scores used to validate the Haptic Visual Discrimination Test, Information and Digit Symbol subtests of the WAIS. There were no controls for the Bender Gestalt as scored by the Embree/Butler scoring system but it has been found to discriminate between schizophrenics and brain damaged patients using this scoring system (Henderson, 1981). An analysis of variance indicated that the groups did not differ significantly in age ($F_{1,79} = .05$, $p > .05$), sex ($F_{1,79} = 1.15$, $p > .05$), or education ($F_{1,79} = 1.81$, $p > .05$)

<u>Instruments</u>

The Haptic Visual Discrimination Test consists of 48 items arranged to provide discriminating measures of shape, size, texture, and spatial configuration. Each category contains 12 items. The shape category consists of a combination of various Euclidean shapes: circle, ellipse, square, triangle, trapezoid, pentagon, hexagon, cross and star. The size category consists of solid cubes, hexagon nuts, cylinders and round knobs. The difference in the size of two consecutive objects follows a progression. The texture category consists of objects having different fabric meshes, fine to heavy nap, and smooth surfaces. The configuration category consists of different size cylinders and posts which are sequentially arranged to form a variety of shapes. The standardized procedure of administration includes a cloth screen to obscure the subject's vision of the hand during object palpation and manipulation. The subject is then asked to visually identify the object on a photographic plate, by pointing to the correct image with the free hand. Each photographic plate contains five stimulus objects in the same stimulus. For example, the subject is given a square shaped object to palpate and then is instructed to indicate with the free hand the item on the chart that matches the one that is being palpated.

Each of the 48 items is administered according to this procedure and the score is the total number of correct items. The mean for normal adults is 35 with a standard deviation of 4. The test-retest reliability is r = .91.

The Bender Gestalt Test, a test of visual motor perception, consists of nine test cards and the subject is asked to copy the designs one at a time with a pencil. The Embree/Butler scoring system uses a weighted scoring system. The system of error includes partial rotation (five points), ommission of angles (five points), added angles (four points), overlap difficulty (four points), distortion (four points), tremor (four points), embellishments (three points), lack of closure (three points), and angles flattening (three points). The interrater reliability for this scoring system was r = .96 (see Appendix A).

The Information subtest of the WAIS consists of 29 items dealing with general information. The Digit Symbol subtest requires the subject to fill in spaces with symbols associated with numbers one through nine. There is a 90 second time limit.

The symptom rating scale includes five symptoms (autism, ambivalence, affect, thought process, and paranoia). Each symptom was rated by the examiner on a one to five scale, one being low and five being high. The examiner was trained in the use of this rating scale, however, it was recognized that the scale score assigned was influenced by the clinician's judgment and past experience. In this rating scale, autism was defined as a form of thinking in which the thoughts are largely narcissistic and egocentric, with emphasis on subjectivity rather than objectivity and without regard for reality. This scale was rated from one--none, three--moderate, and five--severe. Ambivalence was defined as the presence of strong and often overwhelming simultaneous contrasting attitudes ideas and feelings and drives toward an object, person, or goal. This scale was rated as one--none, three--moderate, and five--severe. Affect was defined as emotional feeling or tone attached to an object, idea or thought. The term includes inner feelings and their external manifestations. This scale was rated from one--normal affect, three--restricted, and five--inappropriate. Thought process was defined as being manifested by irrelevance and incoherence of the person's verbal productions. It ranged from one--well organized, three--circumstantial, and five--very loose associations or disorganized. Paranoia was defined as gradually developing systematized delusional states involving either grandiosity or persecution. This symptom was rated as one--no evidence, three-loosely formed delusion, and five--a very well formed, systematized delusion (see Appendix B).

<u>Procedure</u>

Each subject in the schizophrenia group was administered the Haptic Visual Discrimination Test, Bender Gestalt and the Information and Digit Symbol subtests of the WAIS. Tests were administered by the principal invesigator and a licensed psychologist. In all cases, the subjects' rights were protected according to the standards of the American Psychological Association as well as those of the Dallas County Mental Health and Mental Retardation Center (Appendix C). The standard procedures and instructions were used for each test.

Each subject was first administered the HVDT to either the right or left hand. To avoid experimental bias, the first presentation hand was alternated from subject to subject. A discrimanant analysis showed no significant difference between first hand presentation ($p = .153$). Following the first presentation of the HDVT, each subject was then administered the Bender Gestalt, Information and Digit Symbol subtests from the WAIS. Finally, the HVDT was then presented for a second time to the opposite hand from that given in the first presentation. After all tests were completed, the examiner then completed the symptom rating scale.

The HVDT was scored according to the standardized age norms for the test. The Bender Gestalt was scored by the Embree/Butler scoring system. The standardized age norms were used for the Information and Digit Symbol subtests. Test data for the brain damaged subjects was scored according to these same norms. The normal group was defined by the standardized age norm scores for each test.

In order to test the hypothesis that some of the schizophrenics would show lateralized sensory integration deficits, a right and left hemisphere index was created. This index was computed for both the schizophrenic and brain damaged groups. If the left hand HVDT total score was lowest, the right hemisphere index was defined as the right hand HVDT total score minus the left hand HVDT total score. Conversely, if the right hand HVDT total score was lowest, the left hemisphere index was defined as the left hand HVDT total score minus the right hand HVDT total score. The formula for deriving the hemisphere index was:

$$\left(\frac{\text{Higher hand HVDT total score} - \text{lower hand HVDT total score}}{\text{Standard Deviation of the Raw Score (4)}}\right)$$

$$\times$$

$$\text{Standard Deviation of the Scaled Score (3)}$$

If the computed index was less than $\pm$ 3 scaled scores, the performance was within the normal range of variability. If the computed index was more than $\pm$ 3, scaled scores performance indicated lateralized dysfunction.

Results

In order to answer the hypotheses posed at the end of the literature review, several types of statistical analyses were utilized. These included the t-test, multiple discriminant analysis, analysis of variance and factor analysis. In order to minimize suppression of the HVDT scores since both total and subtest scores were used as dependent variables, two multiple discriminant analyses were computed for each group comparison. The first multiple discriminant analysis used the Total Score from each test (Bender Gestalt, Information subtest, Digit Symbol subtest, and right and left hand HVDT, and the right and left hand hemisphere indices). The second multiple discriminant analysis used the subtest scores only, for the right and left hand HVDT. No relationship was found and no further analyses were made using the symptom rating scale.

Hypothesis one was whether normals defined, as the standardized age scaled scores, performed differently than schizophrenics on the Information, Digit Symbol and HVDT. The obtained data was submitted to t-test analysis. As can be seen in Table 1, results of the t-tests using scaled age scores showed statistically significant differences between the groups for all test comparisons.

Table 1

T-Test Comparisons of Age Scaled Scores of the Information Digit Symbol and Right and Left Hand HVDT Test Results for the Schizophrenic and Normal Groups

	Normal		Schizophrenic		t-Score	Significance
	$\bar{X}$	S.D.	$\bar{X}$	S.D.		
	500		40			
Information	10.0	3.0	8.68	2.68	2.83	$p < .01$
Digit Symbol	10.0	3.0	7.00	1.83	9.30	$p < .001$
Right Hand HVDT Total	10.0	3.0	8.4	3.6	2.50	$p < .05$
Left Hand HVDT Total	10.0	3.0	7.9	3.7	3.20	$p < .01$

In order to test hypotheses two and three, that schizophrenics performed differently than brain damaged subjects, mean test scores were computed. Table 2 shows the mean and standard deviations and F values for both groups. Statistically significant F values for 8 of the 15 variables were obtained. The Bender Gestalt, the right and left hand configuration subtests of the HVDT, the left hand HVDT total, and the left hemisphere index were all significant at the .05 level. The right and left hand size subtest, and the right hand total score of the HVDT were significant at the .01 level.

Table 2

Means, Standard Deviations, and Analysis of Variance of Scores for the Bender Gestalt, Information, Digit Symbol, HVDT Total and Subtests for Right and Left Hands and the Right and Left Hemisphere Indices of the Schizophrenic and Brain Damaged Group

Test	Schizophrenics		Brain Damaged		
	X	S.D.	X	S.D.	F
Bender	6.60	6.60	10.08	9.14	3.804*
Information	8.58	2.68	8.00	2.71	1.254
Digit Symbol	7.00	1.83	6.85	2.30	0.104
HVDT Total-Righthand	34.00	4.74	29.35	8.05	9.90**
Shape	10.35	1.33	9.58	2.63	2.765
Size	8.85	1.64	7.43	2.85	7.491**
Texture	6.98	2.06	6.00	2.52	3.591
Configuration	7.88	2.24	6.53	2.49	6.486*
HVDT Total-Lefthand	33.25	5.03	28.80	9.67	6.664*
Shape	10.08	1.35	9.30	3.16	2.032
Size	8.83	2.24	7.23	3.07	7.097**
Texture	6.50	2.25	5.90	2.74	1.142
Configuration	7.85	2.05	6.40	3.13	6.021*

Table 2--Continued

Test	Schizophrenics		Brain Damaged		
	X	S.D.	X	S.D.	F
Right Hemisphere Index	1.58	1.81	2.83	6.11	1.537
Left Hemisphere Index	1.03	1.72	2.45	3.91	4.456*

*p < .05.

**p < .01.

Note. N = 40.

Two multiple discriminant analyses were done in order to further assess the performances between schizophrenic and brain damaged groups. The multiple discriminant analysis using the Total Score for each test as discriminant variables between the schizophrenic group and brain damaged group as a whole may be found in Table 3. The classification table shows that 65% of the schizophrenic subjects and 57.5% of the brain damaged subjects were classified correctly. The overall hit rate was 66.25%. The multiple discriminant analysis generated one discriminant function that was significant at $p = .003$ which accounted for 41% of the variability. As can be seen in Table 3, the variables that contributed the most discriminating power in the discriminant function were the Digit Symbol, right total HVDT, and right hemisphere index scores.

The results of the multiple discriminant analysis using the subtest scores of the HVDT as discriminant variables between the schizophrenic group and the brain damaged group as a whole may be found in Table 4. The classification table

Table 3

Multiple Discriminant Analyses of Total Scores Between Schizophrenic and Brain Damaged Groups

		Classification Table	
	# of cases	Predicted Group Membership	
		Schizophrenic	Brain Damage
Schizophrenic	40	30	10
		75%	25%
Brain Damaged	40	17	23
		42.5%	57.5%

% Cases Correctly Classified = 66.25%

Canonical Correlation = .41

Wilks' Lambda = .836 p = .003

Discriminant Function Coefficients

	Function 1
Digit Symbol	-0.334
Right Hand HVDT Total	1.069
Right Hemisphere Index	-0.531

shows 70% of the schizophrenic subjects and 57.5% of the brain damaged subjects were classified correctly, with an overall hit rate of 66.25%. The multiple discriminant analysis generated one discriminant function that was significant at p = .004 which accounted for 40% of the variability. As can be seen in Table 4, the variables that contributed the most discriminating power to the discriminant function were the right and left hand size, and right and left hand configuration subtests.

Table 4

Multiple Discriminant Analysis of HVDT Subtests Between the Schizophrenic and Brain Damaged Groups

		Classification Table	
	# of cases	Predicted Group Membership	
		Schizophrenic	Brain Damaged
Schizophrenic	40	28	12
		70%	30%
Brain Damaged	40	15	25
		37.5%	62.5%

% Cases Correctly Classified = 66.25%

Canonical Correlation = .40

Wilks' Lambda = .84   p = .004

Discriminant Function Coefficients

	Function 1
Right Size	0.59
Left Size	0.43
Left Configuration	0.45

Hypothesis four was that the tests could discriminate between acute and chronic schizophrenics and acute and chronic brain damaged subjects. In order to test this hypothesis, the data obtained was first submitted to a discriminant analysis. The results showed that there were no significant differences between the acute and chronic schizophrenic subjects (F = .087, df = 4, 73, p = .52). The results did show a statistically significant difference between the acute and chronic brain damaged subjects (F = 5.14, df = 4, 73, p = .001).

A multiple discriminant analysis was then computed for the Total Score using the schizophrenic group, the acute brain damaged group, and the chronic brain damaged group as group membership variables. The Total Score results may be found on Table 5. The classification table shows that 90% of the schizophrenic group, 18.2% of the acute brain damaged group, and 34.5% of the chronic brain damaged group were classified correctly, with an overall hit rate of 60.0%. The remaining 10% of the schizophrenic group was misclassified as chronic brain damaged. Of the remaining 82% of the acute brain damaged group, 72.7% were misclassfied as schizophrenic, and 9.1% misclassified as chronic brain damaged. Of the remaining 65.5% of the chronic brain damaged group, only 6.9% were misclassfied as acute brain damaged and 58.6% were misclassified as schizophrenic. The multiple discrimiant analysis generated two discriminant functions which were significant at $p = .0001$ level and $p = .002$ level. The first function accounted for 40% of the variability while the second function accounted for 34%. As can be seen in Table 5, the two variables that contributed the most discriminating power to the two discriminant functions were the left hand HVDT and the left hemisphere index.

A multiple discriminant analysis was computed for the HVDT subtest scores between the schizophrenic group and the acute and chronic brain damaged groups. The results are

Table 5

Multiple Discriminant Analysis of Total Scores Between the Schizophrenic Group (G 1), Acute (G 2), and Chronic (G 3) Brain Damaged Groups

		Classification Table		
	# of cases	Predicted Group Membership		
		G 1	G 2	G 3
G 1	40	36	0	4
		90.0%	0.0%	10.0%
G 2	11	8	2	1
		72.7%	18.2%	9.1%
G 3	29	17	2	10
		58.6%	6.9%	34.5%

% Cases Correectly Classified = 60.0%

Canoncial Correlation Function 1 = 0.04 Function 2 = 0.34

Wilk's Lambda	Function 1 = 0.74	p = 0.0001
	Function 2 = 0.88	p = 0.002

Discriminant Function Coefficients

	Function 1	Function 2
Left Hand Total	0.973	0.271
Left Hemisphere Index	-0.404	0.925

shown in Table 6. The classification table shows 77.5% of the schizophrenic group, 27.3% of the acute brain damaged group, and 44.8% of the chronic brain damaged group were classified correctly, with an overall hit rate of 58.75%. As can be seen in Table 6, two discriminant functions were significant at the p = .002 level and p = .02 level. The first discriminant function accounted for 43% of the variability and the second discriminant function accounted for 34% of the variability. The variables that contributed the most discriminating power to the discriminant function were the right and left hand size subtests and the right and left hand configuration subtest.

Table 6

Multiple Discriminant Analyses for HVDT Subtests Between the Schizophrenic (G 1), and Acute (G 2), and Chronic (G 3) Brain Damaged Groups

		Classification Table		
	# of cases	Predicted Group Membership		
		G 1	G 2	G 3
G 1	40	31	1	8
		77.5%	2.5%	20.0%
G 2	11	6	3	2
		54.4%	27.3%	18.2%
G 3	29	13	3	13
		44.8%	10.3%	44.8%

% Cases Correctly Classified = 58.7%

Canonical Correlation Function 1 = 0.43

Function 2 = 0.34

Wilk's Lambda Function 1 = 0.72 p = 0.002

Function 2 = 0.88 p = 0.02

Table 6--Continued

	Classification Table		
# of Cases	Predicted Group Membership		
	G1	G 2	G 3

Discriminant Function Coefficients

	Function 1	Function 2
Right Size	0.375	0.315
Right Configuration	-0.281	0.950
Left Size	0.475	0.060
Left Configuration	0.751	-0.650

It was found as can be seen in Table 2, that the tests could discriminate between the schizophrenic group and brain damaged group as a whole. In order to further refine this analysis and begin to examine hypothesis five that the performance by the schizophrenic group would show a lateralized sensory integration deficit, a multiple discriminant analysis was computed using the subgroups of the brain damaged group. The subgoups were right hemisphere (n = 10), left hemisphere (n = 10), and diffuse (n = 20) brain damaged groups.

The results of the multiple discriminant analysis using the Total Scores between the schizophrenic group and the right hemisphere, left hemisphere, and diffuse brain damaged groups can be found in Table 7. The classification table shows that 90% of the schizophrenic group, 30% of the right hemisphere group, 30% of the left hemisphere group, and 45% of the diffuse brain damaged group were classified correctly. The overall hit rate was 63.75%. The multiple discriminant analysis generated three discriminant functions which were significant at p = .00001 level, p = .0001 level, and p = .001 level. The variables that contributed to the discriminant function model were the Digit Symbol, right hand HVDT total, left hand HVDT total, and the right hemisphere index.

Table 7

Multiple Discriminant Analysis of the Total Scores Between the Schizophrenic Group (G 1), and Right Hemisphere (G 2), Left Hemisphere (G 3), and Diffuse (G 4) Brain Damaged Groups

Classification Table

Actual Group	# of Cases	Predicted Group Membership			
		G 1	G 2	G 3	G 4
G 1	40	36	0	1	3
		90.0%	0.0%	2.5%	7.5%
G 2	10	7	3	0	0
		70.0%	30.0%	0.0%	0.0%
G 3	10	6	0	3	1
		60.0%	0.0%	30.0%	10.0%
G 4	20	10	0	1	9
		50.0%	0.0%	5.0%	45.0%

% Cases Correctly Classified: 63.75%

Table 7--Continued

Classification Table					
Actual Group	# of Cases	Predicted Group Membership			
		G 1	G 2	G 3	G 4

	Canonical Correlation	Wilk's Lambda	
Function 1	0.594	0.449	p = .00001
Function 2	0.413	0.693	p = .0001
Function 3	0.405	0.836	p = .001

Discriminat Function Coefficients

	Function 1	Function 2	Function 3
Digit Symbol	-0.355	0.213	-0.239
Right Hand Total	0.376	-1.801	0.144
Left Hand Total	0.077	2.273	1.341
Right Hemisphere Index	0.976	2.014	0.703

A multiple discriminant analysis was computed for the HVDT subtest scores between the schizophrenic group and the right hemisphere, left hemisphere, and diffuse brain damaged groups. The results may be found on Table 8. The classification table shows that 85% of the schizophrenic group, 30% of the right hemisphere, 30% of the left hemisphere group, and 60% of the diffuse brain damaged group were classified correctly. The overall hit rate was 65%. As can be seen in Table 8, the multiple discriminant analysis generated two discriminant functions that were significant at the p = .00001 level and p = .01. The variables that contributed the most to the discriminating power of the discriminant function were right and left hand shape, right and left hand configuration, left hand size and left hand texture subtests.

Table 8

Multiple Discriminant Analysis for the HVDT Subtests Between the Schizophrenic Group (G 1), and Right Hemisphere (G 2), Left Hemisphere (G 3), and Diffuse (G 4) Brain Damaged Groups

Classification Table

Actual Group	# of Cases	Predicted Group Membership			
		G 1	G 2	G 3	G 4
G 1	40	34	0	1	5
		85.0%	0.0%	2.5%	12.5%
G 2	10	7	3	0	0
		70.0%	30.0%	0.0%	0.0%
G 3	10	5	0	3	2
		50.0%	0.0%	30.0%	20.0%
G 4	20	8	0	0	12
		40.0%	0.0%	0.0%	60.0%

% Cases Correctly Classified: 65.0%

	Canonical Correlational	Wilk's Lambda	Significance
Function 1	0.663	0.414	p = .0001
Function 2	0.431	0.741	p = .01

Table 8--Continued

Classification Table					
Actual Group	# of Cases	Predicted Group Membership			
		G 1	G 2	G 3	G 4

Discriminant Function Coefficients

	Function 1	Function 2
Right Shape	0.759	0.706
Right Configuration	0.689	-0.130
Left Shape	-0.915	-0.600
Left Size	0.388	0.688
Left Texture	-0.305	0.415
Left Configuration	-0.466	0.437

As can been seen in Tables 7 and 8, the classification tables showed that a large percentage (approximately 60%) of the lateralized brain damaged groups were misclassified as schizophrenics. The hit rate for the schizophrenic group was between 85 and 90%. When the schizophrenic group was misclassified in both multiple discriminant analyses they were misclassified as left hemisphere or diffuse brain damage. Also a large percentage (40 to 50%) of the diffuse brain damaged group were misclassified not as lateralized brain damaged but as schizophrenic.

In order to test hypothesis six that the performance by the schizophrenic population showing a lateralized sensory integration deficit would be similar to the performance by one of the brain damaged subgroups several multiple discriminant analyses were computed using only those schizophrenic subjects that had a significant right or left hemisphere index. These schizophrenic subjects and right hemisphere, left hemisphere and diffuse brain damaged groups were used as group membership variables.

A multiple discriminant analysis was computed for the Total Scores between the schizophrenic subjects showing a significant right hemisphere index, and right hemisphere, left hemisphere and diffuse brain damaged groups. The results may be found in Table 9. The classification table shows 69.2% of the schizophrenic group, 30% of the right hemisphere group, 60% of the left hemisphere group, and 90% of the diffuse brain damaged group were classified correctly. As can seen on Table 9, the schizophrenic group showing a significant right hemisphere index when misclassified were misclassified as diffuse brain damaged. Also, when the right hemisphere brain damaged group was misclassified, 60% were misclassified as schizophrenic. The overall hit rate was 67.92%. Two discriminant functions were significant at the p = .0001 level and p = .01. The first function accounted for 65% of the variability and the second function accounted for 47% of the variability. The variables that contributed the most discriminating power to the discriminant function model were Digit Symbol, right hand HVDT total, left hand HVDT total, and right hemisphere index.

Table 9

Multiple Discriminant Analysis for Total Score Between Right Hemisphere Index Computed for Schizophrenic (G 1), Right Hemisphere (G 2), Left Hemisphere (G 3), and Diffuse (G 4) Brain Damaged Groups

Classification Table

Actual Group	# of Cases	Predicted Group Membership			
		G 1	G 2	G 3	G 4
G 1	13	9	0	0	4
		69.2%	0.0%	0.0%	30.8%
G 2	10	6	3	0	1
		60.0%	30.0%	0.0%	10.0%
G 3	10	2	0	6	2
		20.0%	0.0%	60.0%	20.0%
G 4	20	1	0	1	18
		5.0%	0.0%	5.0%	90.0%

% Cases Correctly Classified: 67.92%

	Canonical Correlation	Wilk's Lambda	Significance
Function 1	0.652	0.407	p = .0001
Function 2	0.476	0.708	p = .01

Discriminant Function Coefficients

	Function 1	Function 2
Digit Symbol	-0.484	-0.004
Right Total	0.649	-1.327
Left Total	0.066	2.780
Right Hemisphere Index	0.876	2.257

A multiple discriminant analysis was computed for the HVDT subtest scores between the schizophrenics showing a significant right hemisphere index, right hemisphere, left hemisphere, and diffuse brain damaged groups. The results may be found on Table 10. The classification tables shows 53.8% of the schizophrenic group, 50% of the right hemisphere group, 40% of the left hemisphere group, and 70% of the diffuse brain damaged group were classified correctly. The overall hit rate which was much lower than when using the Total Scores between these same groups was 56.60%. Two discriminant functions were significant at the p = .0001 level and p = .05 level. The variables that contributed the most discriminating power to the discriminant function model were right and left hand texture and right and left hand configuration subtests.

Table 10

Multiple Discriminant Analysis for HVDT Subtest Scores Between Right Hemisphere Index Computed for Schizophrenic (G 1), Hemisphere (G 2), Left Hemisphere (G 3), and Diffuse (G 4), Brain Damaged Groups

Classification Table

Actual Group	# of Cases	Predicted Group Membership G 1	G 2	G 3	G 4
G 1	13	7	1	2	3
		53.8%	7.7%	15.4%	23.1%
G 2	10	2	5	0	3
		20.0%	50.0%	0.0%	30.0%

Table 10--Continued

Classification Table

Actual Group	# of Cases	Predicted Group Membership			
		G 1	G 2	G 3	G 4
G 3	10	2	0	4	4
		20.0%	0.0%	40.0%	40.0%
G 4	20	2	1	3	14
		10.0%	5.0%	15.0%	70.0%

% Cases Correctly Classified: 56.60%

	Canonical Correlation	Wilk's Lambda	Significance
Function 1	0.686	0.408	p = .0001
Function 2	0.394	0.770	p = .04

Discriminant Function Coefficients

	Function 1	Function 2
Right Texture	-0.054	0.940
Right Configuration	-0.930	0.093
Left Texture	0.695	0.128
Left Configuration	0.609	-0.021

Table 11 shows the results of the multiple discriminant analysis computed for the Total Scores between the schizophrenic subjects showing a significant left hemisphere index and right hemisphere, left hemisphere, and diffuse brain damaged groups. The classification table shows that 14.3% of the schizophrenic group, 60% of the right hemisphere group, 60% of the left hemisphere group, and 80% of the diffuse brain damaged group were classified correctly. As can be seen from the table only one brain damaged subject was misclassified as schizophrenic. When the brain damaged subjects were misclassified they were misclassified as other types of brain damage and not as schizophrenics. Also, 43% of the schizophrenic group were misclassified as left hemisphere brain damage and 43% misclassified as diffuse brain damage. The overall hit rate was 61.7%. As can be seen in Table 11, two discriminant functions were significant at the p = .0004 level and p = .05 level. The variables that contributed the most discriminating power to the discriminant function model were Information, Digit Symbol, right hand HVDT total, left hand HVDT total and right hemisphere index. As can be seen this is the only multiple discriminant analysis where the Information subtest contributed to the discriminating power of the discriminant function.

Table 11

Multiple Discriminant Analysis for Total Scores Between Left Hemisphere Index Computed for Schizophrenics (G 1) Right Hemisphere (G 2), Left Hemisphere (G 3), and Diffuse (G 4) Brain Damaged Groups

Classification Table

Actual Group	# of Cases	Predicted Group Membership			
		G 1	G 2	G 3	G 4
G 1	7	1	0	3	3
		14.3%	0.0%	42.9%	42.9%

Table 11--Continued

Classification Table

Actual Group	# of Cases	Predicted Group Membership			
		G 1	G 2	G 3	G 4
G 2	10	0	6	2	2
		0.0%	60.0%	20.0%	20.0%
G 3	10	0	0	6	4
		0.0%	0.0%	60.0%	40.0%
G 4	20	1	1	2	16
		5.0%	5.0%	10.0%	80.0%

% Cases Correctly Classified: 61.70%

	Canonical Correlation	Wilk's Lambda	Significance
Function 1	0.667	0.380	$p = .0004$
Function 2	0.549	0.685	$p = .05$

Discriminant Function Coefficients

	Function 1	Function 2
Information	-0.333	-0.287
Right Symbol	-0.496	-0.034
Right Total	0.630	-1.069
Left Total	0.049	2.674
Right Hemisphere Index	0.929	2.115

A multiple discriminant analysis was computed for the HVDT subtest scores between the schizophrenic subjects showing a significant left hemisphere index, and right hemisphere, left hemisphere, and diffuse brain damaged groups. The results may be found on Table 12. The classification table shows 0% of the schizophrenic subjects, 60% of the right hemisphere subjects, 60% of the left hemisphere subjects, and 85% of the diffuse brain damaged subjects were classified correctly. As can be seen from the classification table none of the schizophrenic subjects were classified correctly and none of the brain damaged subjects were misclassfied as schizophrenia. The overall hit rate was 61.70%. As can been seen in Table 12, the multiple discriminant analysis generated one discriminant function that was significant at the $p = .0002$ level. The variables that contributed the most discriminating power to the discriminant function model were right and left hand texture and right and left hand configuration subtests.

Table 12

Multiple Discriminant Analysis for HVDT Subtest Scores Between Left Hemisphere Index Computed for Schizophrenics (G 1), Right Hemisphere (G 2), Left Hemisphere (G 3), and Diffuse (G 4) Brain Damaged Groups

Classification Table

Actual Group	# of Cases	Predicted Group Membership			
		G 1	G 2	G 3	G 4
G 1	7	0	0	3	4
		0.0%	0.0%	42.9%	57.1%
G 2	10	0	6	0	4
		0.0%	60.0%	0.0%	40.0%

Table 12--Continued

Classification Table

Actual Group	# of Cases	Predicted Group Membership			
		G 1	G 2	G 3	G 4
G 3	10	0	0	6	4
		0.0%	0.0%	60.0%	40.0%
G 4	20	0	1	2	17
		0.0%	5.0%	10.0%	85.0%

% Cases Correctly Classified: 61.70%

	Canonical Correlation	Wilk's Lambda	Significance
Function 1	0.721	0.413	0.0002

Discriminant Function Coefficients

	Function 1
Right Texture	0.173
Right Configuration	-1.007
Left Texture	0.644
Left Configuration	0.728

In most of the multiple discriminant analyses the overall hit rate using the Total Scores and HVDT subtests were similar. In order to have a better understanding of how the schizophrenic and brain damaged groups performed in reference to each other and to normals, their mean scaled scores for the HVDT subtests were plotted for the right and left hands. Figure 1 shows the right and left hand patterns

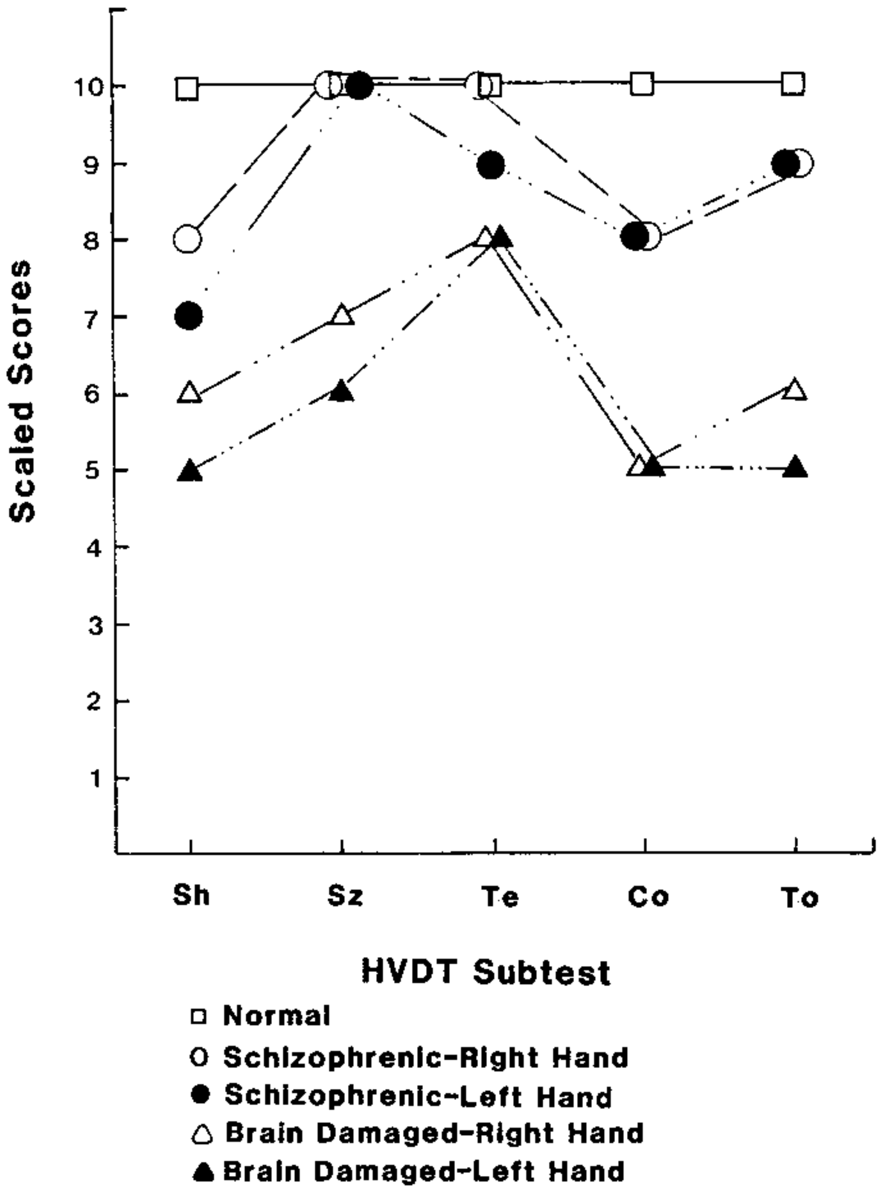

Figure 1. Pattern of performance of right and left hand HVDT subtests (shape, size, texture, configuration, total) for the schizophrenic and brain damaged groups.

for normals, schizophrenic and brain damaged groups. The shape and configuration subtest scores were the lowest within group scores for the schizophrenic group, while texture was the highest within group score for the brain damaged group. Figure 2 shows the patterns of the normal, schizophrenic, right hemisphere, left hemisphere and diffuse brain damaged groups for the right hand presentation of the HVDT. Scaled score patterns of the schizophrenic and diffuse groups appear similar but the scores were lower for the diffuse brain damage group. The score levels were similar for the schizophrenic and right hemisphere brain damage group while both pattern and level for the left hemisphere group was different. Figure 3 shows the pattern of these same groups for the left hand presentation of the HVDT. Scaled score patterns of the schizophrenic and right hemisphere brain damaged groups appear similar although the level of performance is lower for the right hemisphere brain damaged group. The shape and configuration subtests were the lowest scores for both of these groups.

Post hoc factor analyses were computed for the schizophrenic group and brain damaged subgroups. These were done in an attempt to assess which HVDT subtest or combination of subtests were accounting for the most variance in each group. A factor analysis performed by McCarron and Dial (1979) for normals showed that size and texture loaded heavily on one factor while shape and configuration loaded heavily on a second factor. High factor loadings (above

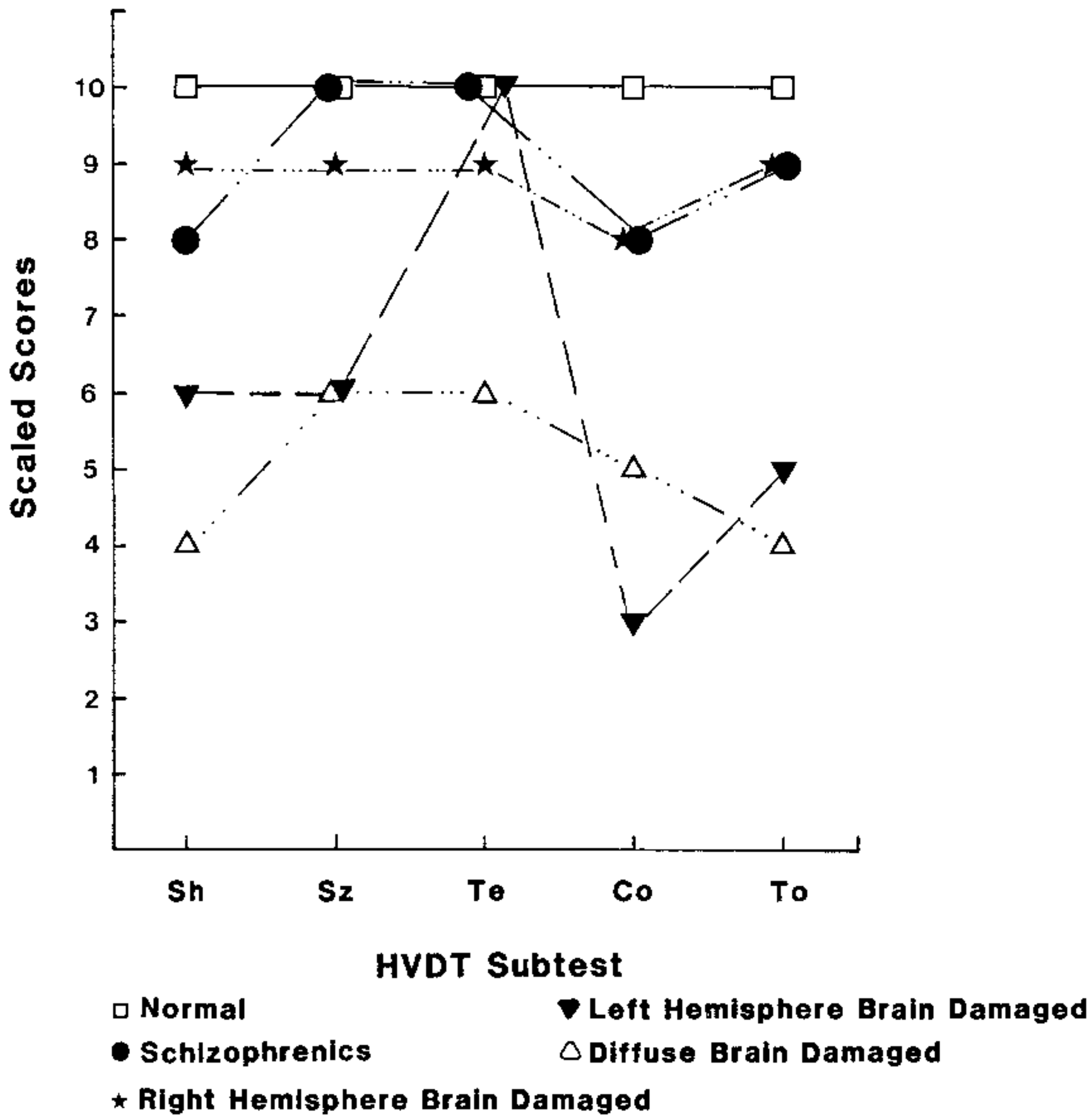

Figure 2. Pattern of performance of right hand HVDT subtests (shape, size, texture, configuration, total) for normals, schizophrenic group, and right hemisphere, left hemisphere and diffuse brain damaged groups.

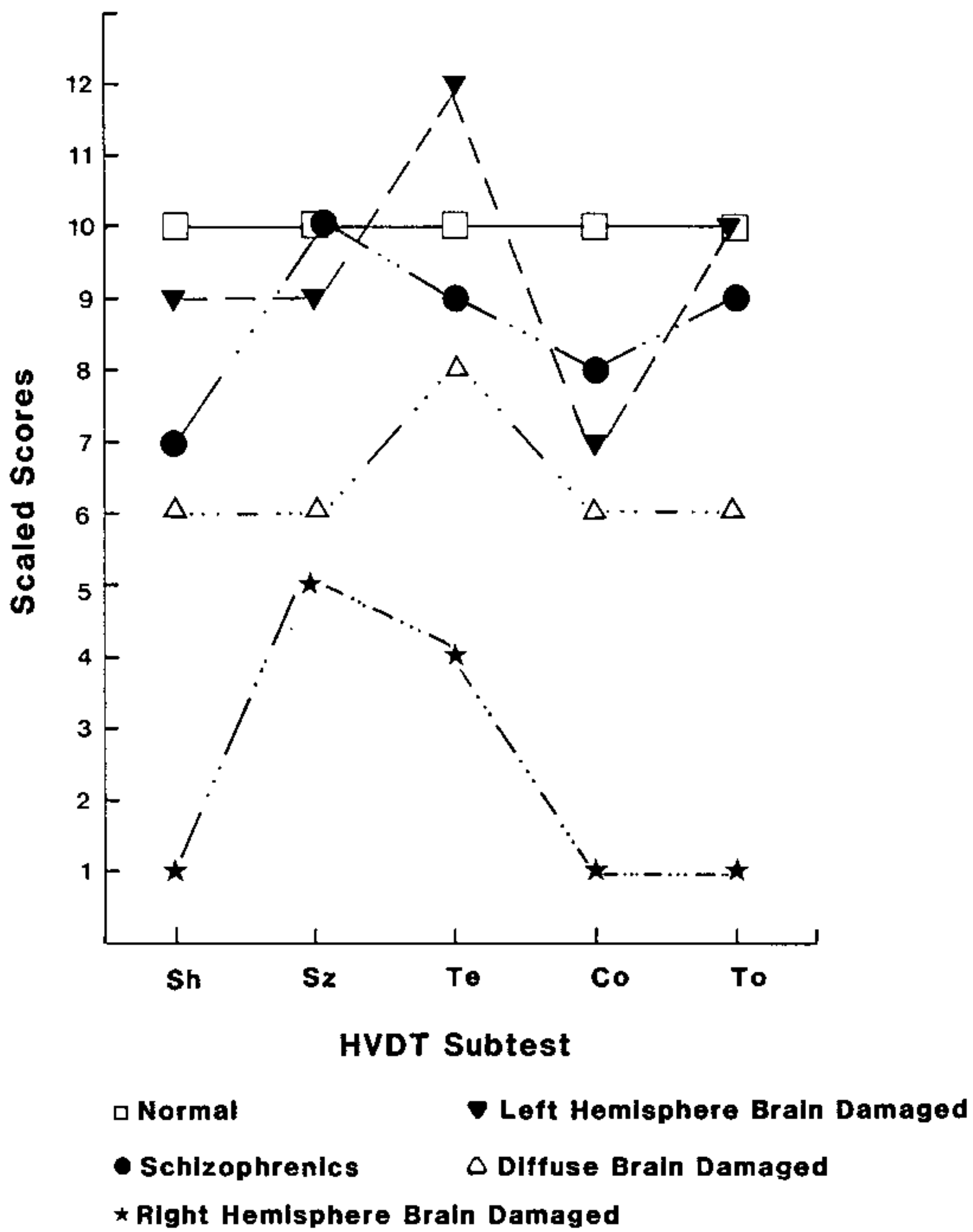

Figure 3. Pattern of performance of left hand HVDT subtests (shape, size, texture, configuration, total) for normals, schizophrenic group and right hemisphere, left hemisphere, and diffuse brain damaged groups.

.50) were identified as contibuting components for a particular factor.

Results of the factor analysis for the schizophrenic group may be found on Table 13. The factor analysis showed that 2 components or subtests had eigenvalues above 1.0. The varimax rotated factor matrix resolved into two factors which accounted for 62.4% and 37.6% of the total variance respectively. The variables that loaded heavily on Factor one were right hand size, texture, and right and left configuration subtests while right and left hand shape loaded heavily on Factor two.

Table 13

Post Hoc Factor Analysis for the Schizophrenic Group, Data Represent Eigenvalue, Percent of Variance, Cumulative Variance and Varimax Rotated Factor Matrix for Both Right and Left Hand HVDT Subtest Scores

HVDT Components	Factor Eigenvalues	% of Variance	Cumulative
Right Shape	2.902	36.3	36.3
Right Size	1.827	22.8	59.1
Right Texture	0.913	11.4	70.5
Right Configuration	0.791	9.9	80.4
Left Shape	0.519	6.5	86.9
Left Size	0.429	5.4	92.3
Left Texture	0.396	4.9	97.2
Left Configuration	0.224	2.8	100.0

Table 13--Continued

HVDT Components	Factor 1	Factor 2
Right Shape	-0.235	0.817
Right Size	0.719	-0.047
Right Texture	0.658	-0.081
Right Configuration	0.684	0.429
Left Shape	0.111	0.725
Left Size	0.462	-0.001
Left Texture	0.498	-0.046
Left Configuration	0.578	-0.046
Percent of Variance	62.4	37.6

Results of the factor analysis for the right hemisphere brain damaged group may be found on Table 14. The factor analysis had three components or subtests that had eigen-values above 1.0. The varimax rotated factor matrix resolved into three factors that accounted for 63.2%, 23.3%, and 13.9% of the total variance respectively. As can be seen on Table 14, left hand shape, size, and texture and right hand confi-guration loaded heavily on Factor 1, while right hand size and left hand shape and texture loaded heavily on Factor two. Only right hand shape was loaded heavily on Factor three.

Results of the factor analysis for the left hemisphere brain damaged group may be found on Table 15. The factor analysis showed that two components had eigenvalues above

Table 14

Post Hoc Factor Analyses of the Right Hemisphere Brain Damaged Group, Data Represent Eigenvalue, Percent of of Variance, Cumulative Variance, and Varimax Rotated Factor Matrix, for Both Right and Left Hand HVDT Subtest Scores

HVDT Components	Factor Eigenvalues	% of Variance	Cumulative
Right Shape	3.976	49.7	49.7
Right Size	1.605	20.1	69.8
Right Texture	1.089	13.6	83.4
Right Configuration	0.836	10.4	93.8
Left Shape	0.250	3.1	97.0
Left Size	0.184	2.3	99.3
Left Texture	0.055	0.7	99.9
Left Configuration	0.004	0.1	100.0

HVDT Compoments	Factor 1	Factor 2	Factor 3
Right Shape	-0.035	0.037	0.996
Right Size	-0.062	-0.640	-0.049
Right Texture	-0.043	-0.377	0.012
Right Configuration	0.878	-0.384	-0.096
Left Shape	0.618	0.621	0.390
Left Size	0.856	0.411	-0.113
Left Texture	0.679	0.566	0.205
Left Configuration	0.970	0.229	0.048
Percent of Variance	63.2	23.2	13.9

Table 15

Post Hoc Factor Analyses for Left Hemisphere Brain Damaged Group, Data Represent Eigenvalue, Percent of Variance, Cumulative Variance, and Varimax Rotated Factor Matrix, for Both Right and Left Hand HVDT Subtest Scores

HVDT Components	Factor Eigenvalues	% of Variance	Cumulative
Right Shape	4.490	56.1	56.1
Right Size	1.316	16.4	72.6
Right Texture	0.992	12.4	85.0
Right Configuration	0.758	9.5	94.5
Left Shape	0.259	3.2	97.7
Left Size	0.099	1.2	98.9
Left Texture	0.079	1.0	99.9
Left Configuration	0.007	0.1	100.0

HVDT Components	Factor 1	Factor 2
Right Shape	0.947	0.139
Right Size	0.698	-0.048
Right Texture	0.877	0.180
Right Configuration	0.726	0.321
Left Shape	0.749	0.572
Left Size	-0.003	0.374
Left Texture	0.069	0.429
Left Configuration	0.579	0.806
Percent of Variance	85.1	14.9

1.0. The varimax rotated factor matrix resolved into two factors that accounted for 85.1% and 14.9% of the total variance respectively. The matrix shows that right and left hand shape and configuration and right hand size and texture loaded heavily on Factor one, while left hand shape and configuration loaded heavily on Factor two.

Results of the factor analysis for the diffuse brain damaged group may be found on Table 16. The factor analysis showed that two components had eigenvalues above 1.0. The varimax rotated factor matrix resolved into two factors that accounted for 76.5% and 23.5% of the total variance respectively. The matrix showed that right and left hand shape and configuration loaded heavily on Factor one, while right and left hand size loaded heavily on Factor two. This factor structure is very similar to those found in normals.

Table 16

Post Hoc Factor Analysis of the Diffuse Brain Damaged Group Data Represent Eigenvalue, Percent of Variance, Cumulative Variance and Varimax Rotated Factor Matrix for Both Right and Left Hand HVDT Subtest Scores

HVDT Components	Eigenvalues	% of Variance	Cumulative
Right Shape	3.609	45.1	45.1
Right Size	1.531	19.1	64.3
Right Texture	0.791	9.9	74.2
Right Configuration	0.775	9.7	83.8
Left Shape	0.513	6.4	90.3

Table 16--Continued

HVDT Components	Eigenvalue	% of Variance	Cumulative
Left Size	0.440	5.5	95.8
Left Texture	0.311	3.9	99.6
Left Configuration	0.028	0.4	100.0

HVDT Components	Factor 1	Factor 2
Right Shape	0.845	0.400
Right Size	0.269	0.737
Right Texture	0.246	0.376
Right Configuration	0.737	0.046
Left Shape	0.881	0.377
Left Size	-0.282	0.623
Left Texture	0.441	0.408
Left Configuration	0.551	-0.059
Percent of Variance	76.5	23.5

Discussion

Overall, the findings of the present investigation strongly suggest that although schizophrenia can be discriminated from normal and brain damaged groups, schizophrenia and brain damage are not mutually exclusive diagnostic categories. Some of the findings suggest that the schizophrenic group has within it a subgroup which in essence does exhibit brain damage symptoms. The present finding regarding sensory integration suggest that the underlying neurological dysfunction in certain schizophrenics may be localized to some extent in the posterior right cerebral hemisphere.

It has generally been accepted by most researchers that the right and left hemisphere have different functions although these functions are not totally exclusive processes in either hemisphere. It is generally thought for most people who are right handed that the left hemisphere specializes in analytic, verbal and cognitive functions, whereas the right hemisphere specializes in visuospatial and synthetic processing.

Before discussing the results of the present study and their implications for psychology the HVDT and what the test measures will be reviewed briefly. The HVDT measures sensory (haptic visual) integration which is conceptualized as being processed in the parietal occipital lobes of the cortex. The HVDT allows the examiner to test both of the individual's hands and make the following inferences using the total scores: a) the subject's ability to integrate haptic or tactual visual sensory information; and b) depending on the hand being tested, the function of the contralateral hemisphere. If the right hand is being tested, the left hemisphere is primarily involved in processing sensory integration whereas if the left hand is being tested, the right hemisphere is primarily involved in processing sensory information. Performance in the right and left presentations of the HVDT in normal or non-brain damaged subjects should be symmetrical, yielding approximately equal scores. The subtests of the HVDT also offer information concerning ability and hemisphere functioning in the area of sensory integration. The factor analysis of the HVDT subtests discussed in the literature review suggests that while size and texture subtests involve both analytic processing and spatial synthesis, they primarily involve analytic processing. Consequently, the ability to do the size and texture subtests depends on the intactness and functioning of the left hemisphere. The shape and configuration subtests involve spatial integration and synthesis and better performance is primarily dependent upon the intactness and functioning of the right hemisphere.

Right and left hemisphere indicies were created from the HVDT total scores. For normal and non-brain damaged subjects, the HVDT total scores are equal and the difference between the two hands is zero. When the difference between the two HVDT total scores is not zero, it is an indication of asymmetry or lateralized dysfunction in the contralateral hemisphere of the lowest total score between the two hands.

In the comparison between normal and the schizophrenic groups, there is a statistically significant difference between both groups on all the tests. Although the HVDT total scores are less for the schizophrenic group than the normals, the HVDT scores for the schizophrenic group are basically equal and symmetrical. That is, the schizophrenic group's level of functioning in the area of sensory integration is only slightly lower than that for the normals.

Hypotheses one and two state that the tests in the present study would discriminate between the schizophrenic and brain damaged groups and that the schizophrenic groups' performance on tasks involving sensory integration would be higher than that of the brain damaged group. The findings support these two hypotheses. Although the HVDT can discriminate between the schizophrenic and brain damaged groups, and the schizophrenic group shows more ability to integrate sensory information, it does not preclude the existence that some schizophrenic subjects may exhibit brain dysfunction (Hypothesis five).

The Bender Gestalt, right and left hand HVDT total scores and the left hemisphere index are significantly different between the schizophrenic and brain damaged groups. The Bender Gestalt does discriminate between the two groups. While the performance of the brain damaged subjects is significantly lower than that for the schizophrenics, the performance of the latter was low enough to suggest they also are experiencing mild brain dysfunction.

The Information and Digit Symbol subtests did not discriminate between these two groups. A possible explanation may be an attention deficit in both groups. In a personal communication with Dr. Raquel Gur, University of Pennsylvania, March, 1982, she discussed some of her current research in attention and arousal. Using the PET scan, Dr. Gur's preliminary findings are that in normals, an increase in arousal and attention is accompanied by an increase in blood flow in right posterior hemisphere. Her research would tend to suggest that a decrease in attention and arousal, or an attention deficit, may involve a dysfunction in the right posterior hemisphere and this may be one phenomenon effecting the performance of the schizophrenic subjects in the present study.

In order to assess lateralized sensory integration dysfunction, a hemisphere index was created. When schizophrenic and brain damaged groups are compared, there is no significant difference in the right hemisphere index. A possible explanation for this finding is that the schizophrenic group has some sensory integration dysfunction in the right hemisphere that is similar in some ways to the brain damaged groups. Another explanation might be found as a function of the items themselves. That is, the HVDT was constructed to measure complex sensory integration as mediated by the higher cortical areas (McCarron & Dial, 1979). Since there is no significant difference between the two groups, lack of difference may be due to the fact that both groups are experiencing dysfunctioning in the parietal occipital higher cortical centers of the right hemisphere.

The left hemisphere index derived for the schizophrenic and brain damaged groups is statistically different, with the left hemisphere index score being lower than the right hemisphere index score for both groups. For normal and non-brain damaged subjects, these indices should be zero. Since they are not zero (Table 2), there is some indication of pathology or dysfunction in both groups. The right hemisphere index is higher than the left hemisphere index also suggesting more lateralized dysfunction in the right hemisphere for both the schizophrenic and brain damaged groups. This finding lends support to the interpretation that certain schizophrenic subjects may show lateralized sensory integration dysfunction (Hypothesis five).

For normal and non-brain damaged subjects the HVDT total scores show symmetrical performances for both hands. The mean HVDT total scores show similar symmetrical performances for both groups on both hands. One possible explanation is that the brain damaged groups represent a composite of individuals having right hemisphere, left hemisphere and diffuse damage. The schizophrenic group also shows symmetrical performances for both hands. As was presented on Tables 9 and 11, thirteen subjects in the schizophrenic group showed right hemisphere sensory integration dysfunction and seven showed left hemisphere sensory integration dysfunction. Although the mean HVDT scores for the schizophrenic group show symmetrical performances, a possible explanation is one that is similar to the brain damaged group. The schizophrenic group represents a composite of subjects showing normal and dysfunctional abilities to process sensory information. These findings strongly suggest that although the schizophrenic group appears to have more ability to integrate sensory information than the brain damaged group, there is a subgroup of schizophrenics that are exhibiting sensory integration dysfunction which supports hypotheses five and six.

The research findings support hypothesis one that the tests would discriminate between the schizophrenic and brain damaged groups. The more salient variables that account for the discrimination between the schizophrenic and brain damaged groups (Table 3) are the right hand HVDT total score, the right hemisphere index and the Digit Symbol subtest. The right hand HVDT total score is a measure of sensory integration functioning in the left posterior hemisphere. It is also a measure of the absence of pathology in the left hemisphere. The right hemisphere index is a measure of pathology in the right hemisphere. While right hemisphere pathology is the second most powerful variable in discriminating between the two groups, sensory integration is by far the more important variable (Table 3). A further interpretation of the data yielded by the discriminant function analysis suggests that to the extent that a subject has more pathology in the right posterior hemisphere, and less ability in the left posterior hemisphere, he is more likely to be classified or diagnosed as brain damaged. Conversly, the more ability in the left posterior hemisphere and the less pathology of the right posterior hemisphere, the more likely the classification or diagnosis of schizophrenia. There is some evidence to suggest that for some of the schizophrenic subjects, the right posterior hemisphere is dysfunctional but not as much as the brain damaged group, and in fact some asymmetry or functioning emerged in the analysis (Table 3).

As was presented in Table 3, the overall hit rate of the discriminant function is moderately significant (66.25%). The classification table shows a 75% hit rate for the schizophrenic group with 25% being misclassified as brain damaged. Those falling into the misclassified category probably represent schizophrenics with left posterior hemisphere dysfunction. Heaton et al. (1978) in their review article reported that of the 14 studies using a mixed (acute and chronic) schizophrenic population and reporting hit rates, the median hit rate was 69%. On the basis of the variables used in the analysis, there is a large number of false positives in the brain damaged group. The false positives are probably due to some of the brain damaged subjects exhibiting a slight dysfunction in the right hemisphere or only slight diffuse brain damage. The difference in performance was highlighted in Figure 1, showing that overall sensory integration functioning of the brain damaged group is less than the schizophrenic group for both hands. Likewise, the schizophrenic group is less than that for the normals group.

The hit rates obtained in the discriminant function between the schizophrenic and brain damaged groups are not highly significant for the differential diagnosis issue. That is, a diagnostician would not make a diagnosis based on these test scores alone. Utilizing these test scores alone is limiting because the schizophrenic group shows some sensory integration dysfunction which is similar to that of the subjects in the brain damaged group. When one takes into account the implication generated by the present finding, it becomes increasingly obvious that in order to arrive at a more accurate diagnosis, other aspects of the individual's functioning need to be assessed: e.g., intellectual functioning, personality characteristics, and mental status.

Golden (1982) discusses the intermediate level of performance of schizophrenics on the Luria Nebraska Neuropsychological Battery and how their performance level often confuses interpretation for the clinician when the choice is between classifying the schizophrenic as normal or brain damaged. In the present study, the schizophrenic group's performance on tasks measuring sensory integration falls between the performance of normal and brain damage. While the data does not support an interpretation that the schizophrenic group is brain damaged, the results do suggest that the schizophrenic group is experiencing at least mild dysfunction in integrating sensory information. The "between level" performance exhibited by schizophrenics is similar to the "intermediate level" found by Golden and the present investigation would tend to support his findings. Consequently, when other aspects of individual functioning are assessed in conjunction with tests aimed at measuring sensory integration processes, a more complete assessment of schizophrenia and brain damage can be derived.

Although the data shows that using the tests in the present study can discriminate between the schizophenic and brain damaged groups and that schizophrenics have more ability in sensory integration, it does not rule out that the schizophrenic group may involve some brain dysfunction. Since Table 3 shows a large percentage of brain damaged subjects misclassified as schizophrenic, one possible explanation for this finding is the degree or severity of dysfunction in the schizophrenic group. Several studies have hypothesized left hemisphere dysfunction in schizophrenics (Gur, 1978, 1979; Gruzelier & Hammond, 1976). The multiple discriminant analysis between the schizophrenic and brain damaged groups suggests that the more intact the left hemisphere and the more dysfunction the right hemisphere, the more likely the classification into appropriate group membership.

In the present study, Hypothesis five states that the performance by the schizophrenic group would show a deficit in lateralized sensory integration. In order to examine Hypothesis five, the brain damaged group was divided into the following subgroups: right hemisphere, left hemisphere, and diffuse.

The analysis between the schizophrenic group and the three brain damaged subgroups can be seen in Table 7. Three discriminant functions obtained significant levels. These discriminant functions involve left hemisphere ability as measured by the right hand HVDT total score; right hemisphere pathology as measured by the right hemisphere index; and right hemisphere sensory integration ability as measured by the left hand HVDT total score. On the basis of these analyses, a subject is classified as schizophrenic or right hemisphere brain damaged if he obtained a high right hand HVDT total score, indicating intact left hemisphere ability. On the other hand, if the right hemisphere index, indicating right hemisphere pathology was high, a subject would be assigned right hemisphere brain damage group membership and possibly also to the schizophrenic. If the left hand HVDT total score is high, the subject would be assigned to the left hemisphere brain damaged group, indicating a more functional right posterior hemisphere. As was presented in Table 7, 90% of the schizophrenic group is classified correctly. However, the right and left hemisphere brain damaged groups are misclassified as schizophrenic 70% to 60% of the time, respectively. Also the diffuse brain damaged subjects, when misclassified are not misclassified into the lateralized brain damaged groups but are assigned schizophrenic group membership. There appears to be some specific deficits in the right hemisphere brain damaged group that confuses them with the schizophrenic group. One possible interpretation of the classification confusion appears to stem from the variables of left hemisphere ability and right hemisphere pathology. The left hemisphere brain damaged group is classified according to right hemisphere ability and there may be some deficits in both the schizophrenic and left hemisphere brain damaged groups that are similar in the right hemisphere, leading to classification confusion. The schizophrenic group as a whole show symmetrical functioning. Because some schizophrenic subjects show asymmetrical dysfunction, it is believed that subjects from the lateralized brain damaged groups are attracted to this group membership and thus are misclassified as schizophrenics.

Figure 2 shows the level of functioning, based on the total scores, is similar for the schizophrenic and right hemisphere brain damaged groups. Also the patterns of the HVDT mean subtests scores for the schizophrenic, right hemisphere brain damaged and diffuse brain damaged groups. As can be seen in Figure 3, patterns for the left hand are similar for the schizophrenic and right hemisphere brain damaged groups although the level of functioning was considerably lower in the right hemisphere brain damaged group. Another possible explanation for the misclassification between these groups may be that a subgroup of schizophrenics is experiencing some dysfunction in the ability to integrate sensory information although this dysfunction may not be as severe as the brain damaged subgroups.

Other investigators have highlighted the difficulty in differentially diagnosing chronic schizophrenia from brain damage subjects (Heaton et al., 1978; Malec, 1978). The present study included chronicity as a variable. That is, the schizophrenic and brain damaged groups were further divided into acute and chronic subgroups within each major group. Hypothesis four states that all the tests in the present study would discriminate between acute and chronic schizophrenic and acute and chronic brain damaged subjects. Also that the acute schizophrenic and brain damaged subgroups would show significantly higher performance on tasks involving sensory integration than would the chronic schizophrenic and brain damaged subgroups. A discriminant analysis failed to show any significant difference between the performance of the acute and chronic schizophrenic subgroups but a significant difference between the acute and chronic brain damaged subgroups did emerge. One possible explanation which would partially account for the lack of significant difference between the schizophrenic subgroup is that all the schizophrenic subjects at the time of testing were currently on three days or less of medication and in an acute phase of illness and schizophrenic symptoms were still prominent. Consequently, it is theorized that the test performance of the two schizophrenic subgroups were equal partially because of the acute phase of the illness and absence or short time on medication. Therefore it is believed they did equally well and no difference was found on the discriminant analysis using all tests.

A multiple discriminant analysis utilizing all test variables was then computed between the schizophrenic group as a whole and the acute and chronic brain damaged subgroups (Table 5). The more salient variables which emerged in the analysis are: the left hand HVDT total score--a measurement of the ability of the right hemisphere to process sensory integration; and the left hemisphere index--a measure of pathology in the left hemisphere. The schizophrenic group appears to have less pathology in the left hemisphere than either the acute or chronic brain damaged groups. In the classification matrix, depicted in Table 5, 90% of the schizophrenic group are classified correctly, yet 72.7% and 58.6% of the acute and chronic brain damaged groups, respectively are misclassified as schizophrenics. Earlier in the discussion, it was pointed out that a large percentage of subjects were misclassified utilizing the group memberships of schizophrenia and right hemisphere, left hemisphere and diffuse brain damaged subgroups. In these analyses group membership for the three brain damaged subgroups was determined by location, i.e., right or left hemisphere or diffuse. In this analysis there was a large percent of misclassifications, 60% to 70% (Table 7). Furthermore, when the group membership for the brain damaged group is determined by the length of time suffering from brain damage (i.e., chronicity) there is still a large percentage of brain damaged subjects being misclassified as schizophrenic, 59% to 73% (Table 5). The findings suggest that whether a brain damaged subject is classified in terms of chronicity or location, the important feature in causing them to be misclassified is that which they have in common with a schizophrenic subgroup: asymmetry in sensory integration functioning. The finding would tend to partially support Golden's investigative efforts related to studies on the Luria Nebraska Neuropsychological Battery. He believes that there is a subgroup of individuals who suffer from both schizophrenia and neurological impairment but the latter is often overlooked by diagnosticians (Golden, 1982). Although chronicity is an important diagnostic criteria in differential diagnosis, findings of the present study suggests that chronicity does not seem to add to the ability of the tests to discriminate between schizophrenics and brain damaged subjects.

As previously discussed, a large percentage of brain damaged subjects based upon either location or chronicity

have been misclassified as schizophrenic group members. One possible explanation for this finding is that a schizophrenic subgroup has some dysfunction in the ability to integrate sensory information. Hypothesis six states that a schizophrenic subgroup would exhibit neurological dysfunction and would be similar to a brain damaged subgroup in the abilities of their members to process sensory information. Those schizophrenic subjects which earned a raw score of three or more on either hemisphere index were defined as having lateralized sensory integration deficits and these subjects were compared with the three brain damage subgroups (Tables 9 and 11). The schizophrenic subjects with neurological dysfunctioning were divided into two subgroups: a) right hemisphere schizophrenics, and b) left hemisphere schizophrenics.
Two multiple discriminant analyses on all test variables were undertaken in order to compare the performances between the three brain damaged subgroups and the two schizophrenic subgroups having neurological dysfunctioning (Tables 9 and 11).

Table 9 shows the results of the comparison between schizophrenics exhibiting right hemisphere dysfunction and the three brain damaged subgroups. An overall hit rate of 67.9% was obtained in correctly classifying subjects to appropriate group memberships. However, understanding the data involves further clarification as to why subjects are misclassified. Although the present analysis involves schizophrenics showing a right hemisphere dysfunction in sensory integration, they are not assigned to the right hemisphere brain damaged group membership but are classified as diffuse brain damaged. Also the right hemisphere brain damaged group are misclassified as members of the schizophrenic subgroup 60% of the time.

When group memberships consist of all schizophrenic subjects and compared to the three brain damaged subgroups, a large percentage of the brain damaged subjects are misclassified as schizophrenics. However, when those schizophrenic subjects exhibiting neurological dsyfunctioning are partialed out into two subgroup memberships (right and left hemispheric dysfunctioning), the left hemisphere and diffuse brain damaged subjects are classified correctly at an improved rate (Table 9). The improvement in the hit rate does not hold for the right hemisphere brain damaged subgroup. That is, they are still being assigned schizophrenic group membership 60% of the time.

One assumption that could be made is that schizophrenics showing right hemisphere dysfunctioning should be misclassified as right hemisphere brain damaged and vice versa. An analysis of the data reveals that the assumption is only partially true: right hemisphere brain damaged subjects are misclassified as schizophrenics exhibiting right hemisphere dysfunctioning. However, when schizophrenics exhibiting right hemisphere dysfunctioning are misclassified, they are not assigned to the right hemisphere brain damaged group but to the diffuse brain damaged group.

Other research investigations (Newlin, 1981) have found left hemisphere cognitive dysfunctioning among schizophrenic subjects. Golden (cited in Newlin, 1981) studied brain density in chronic schizophrenics and hospitalized normal controls. They found that schizophrenics had lower density in left frontal areas, suggesting a localized anatomical abnormality in the schizophrenic subjects. Research investigations related to intellectual functioning generally support the viewpoint that WAIS verbal subtests are mediated in the left hemisphere (Filskov & Boll, 1981).

One finding of the present study is that schizophrenic subjects exhibiting right hemisphere dysfunction are frequently assigned to diffuse brain damage group membership. One explanation for the misclassification is that not only do these schizophrenic subjects have right hemisphere dysfunction but also exhibited deficits on the Information subtest. If the Information subtest is mediated in the left hemisphere, these schizophrenic subjects have dysfunctioning in both the left and right hemisphere. Diffuse brain damaged subjects also have dysfunctioning in both left and right hemispheres. Therefore, it appears that schizophrenics are being assigned diffuse brain damage group membership because they share in common with the diffuse brain damage subjects dysfunctioning in both hemispheres.

In the multiple discriminant analysis between the schizophrenic subjects showing a left hemisphere dysfunction and the three brain damaged subgroups, two disciminant functions are significant (Table 11). The two discriminant functions involve: a) an inability to integrate sensory and motor imformation, and b) right hemisphere ability versus right hemisphere pathology. As was presented in Table 11, only 14.3% of the schizophrenic group showing left hemisphere dysfunction is correctly classified. When misclassified, the schizophrenic subjects are misclassified as left hemisphere brain damage and diffuse brain damage. Also only one brain damaged subject is misclassified as schizophrenic whereas before in the other analyses approximately 60% of the brain damaged subjects were misclassified as schizophrenic. In this analysis, the finding suggests that if a schizophrenic subject has left posterior hemisphere dysfunction, he is more likely to be classified brain damaged. This finding lends support to Hypothesis six that there exists a subgroup of schizophrenia having posterior hemisphere dysfunction in the parietal-occipital lobes. The finding that schizophrenics showing right posterior hemisphere dysfuntion are classified correctly 70% of the time and schizophrenics showing left posterior hemisphere dysfunction are classified correctly only 14% of the time appears to lend additional support to Hypothesis six.

As discussed earlier, previous research efforts have suggested that the left frontal area of the cortex is an area of dysfunction in schizophrenia (Newlin, 1981). The

Information subtest is processed in the left hemisphere (Filskov & Boll, 1981). This would partially explain why these schizophrenic subjects were misclassified as left hemisphere brain damaged and diffuse brain damaged. Also if the left frontal cortex is involved and the schizophrenic subjects showing a right posterior hemisphere sensory integration deficit are misclassified, they are misclassified as diffuse brain damage. The schizophrenic subject showing left posterior hemisphere dysfunction, as suggested by their lowered performance of HVDT subtests are misclassified as having left hemisphere and diffuse brain damaged group membership (Table 11). A partial explanation of the finding, lies in evidence that they have dysfunction in the left posterior hemisphere as measured by HVDT Total Scores and left frontal lobe dysfunction as indicated by lowered Information subtest scores.

The number of schizophrenics having right hemisphere dysfunction is twice that of those having left hemisphere dysfunction in the area of sensory integration. The pattern profiles (Figure 3) depict the relationship between schizophrenics as a whole and right hemisphere brain damaged groups. These groups show high similarity in their patterns on the HVDT subtests. The patterns reveal that shape and configuration subtests are lower than their performance on the other subtests. Shape and configuration subtests are mediated in the right hemisphere (McCarron &

Dial, 1979). Although the subjects in these groups have different group membership, pattern analysis reveals that on two subtests, schizophrenic subjects perform in a manner similar to the right hemisphere brain damaged subjects.

In order to explain the large percentage of misclassification between the schizophrenic and brain damaged subgroups, a model was developed and is presented in Figure 4. The findings in the present study suggest that subgroups have certain deficits in sensory integration--mainly spatial integration, which is conceptualized as being mediated by the right posterior hemisphere. The right hemisphere brain damaged group also has deficits in the right posterior hemisphere and consequently there exists an area of overlap between two subgroups: schizophrenics showing right posterior hemisphere dysfunction and right hemisphere brain damaged. As noted earlier, other researchers have found that schizophrenia may be accompanied by left hemisphere dysfunction, mainly in the frontal lobe. The left hemisphere brain damaged group also has dysfunction in the left frontal lobe, again indicating an area of overlap between these two groups. The diffuse brain damaged group having dysfunction in several areas would also overlap with the schizophrenic group in the right posterior and left frontal areas. It is speculated then that the misclassification confusion stems from the schizophrenic group having some subjects showing lateralized performance deficits

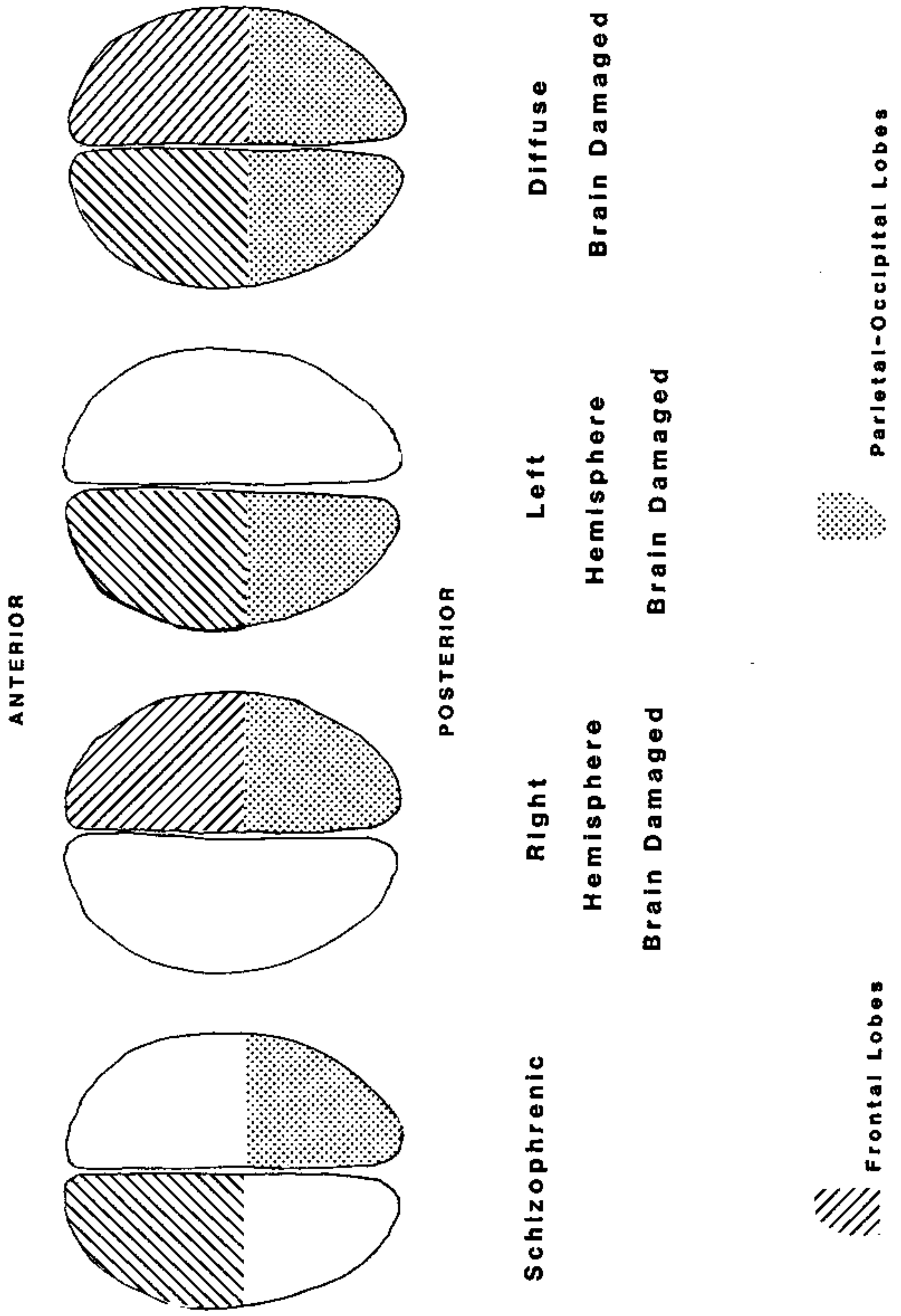

Figure 4. Simplified theoretical model of brain damaged areas (hatch marks) for schizophrenic, right hemisphere, left hemisphere and diffuse brain damaged groups.

(neurological dysfunction) in the area of sensory integration that are similar to the performance deficits of both the lateralized brain damaged groups and the diffuse brain damaged group.

One of the main problems seen in psychology is the question of differential diagnosis between schizophrenia and brain damage. The present investigation shows a subgroup of schizophrenia involving asymmetrical or lateralized dysfunction in sensory integration. While most classification systems recognize schizophrenia and brain damage as mutually exclusive categories, differential diagnosis involving these disorders should examine the possibility that some schizophrenics may have brain dysfunction that behaviorally is similar to brain damage. In order to ascertain a more accurate diagnosis of an individual, the question may not be either schizophrenia or brain damage but: a) schizophrenia, b) brain damage, c) neurological dysfunction accompanied by schizophrenia, or d) schizophrenia accompanied by neurological dysfunction. Differential diagnosis should also include the testing of brain-behavior relations in the area of sensory integration. A diagnostician should not assume that if the diagnosis is schizophrenia, that there is not some sensory integration dysfunction or vice versa.

Multiple discriminant analyses on HVDT subtest scores and Total Scores were performed separately. The overall hit rates were similar. In the analysis between the schizophrenic and brain damaged groups using the HVDT subtest scores, the size subtest was most discriminating. The size subtest is the subtest that involves primarily, analytical processing (McCarron & Dial, 1979). It is believed that complex sensory integration functions measured by the size subtest is best at differentiating schizophrenic and brain damaged subjects. Overall, the HVDT is a test of sensory integration and the HVDT subtest which is most complex--size--is also the subtest which emerged in the analysis as most discriminating. However, in the analysis using HVDT subtests scores between the schizophrenic subjects showing right hemisphere dysfunction, the overall hit rate was much less than for the analysis involving Total Scores. One explanation is that the right hemisphere is mainly involved in processing the HVDT subtests (McCarron & Dial, 1979). When the right hemisphere is dysfunctional in the schizophrenic group as compared to the other three brain damaged subgroups, the HVDT subtests are not able to discriminate between the groups because of the severity or degree of dysfunction in the right hemisphere.

The HVDT subtest measures sensory integration and the higher the performances then the more intact the functioning of the right hemisphere. Multiple discriminant analsyes utilizng HVDT subtest scores between schizophrenics having right hemisphere dysfunction and the three brain damaged subgroups revealed the lowest overall hit rate of any of the multiple discriminant analyses. One explanation for the finding is that better performance on the HVDT is heavily dependent upon right posterior functioning. Three groups--schizophrenics showing right hemisphere dysfunctioning, and the right and diffuse brain damage groups--had right hemisphere dysfunctioning. Consequently, group members were frequently misclassified.

In the multiple discriminant analysis using the HVDT subtest scores between schizophrenics showing a left hemisphere dysfunction and three brain damaged subgroups, the findings are very similar to the analysis using Total Scores. The overall hit rates for both analyses involving either subtests or Total Scores is 61.70%. As can be seen in Table 12, none of the subjects in the schizophrenic group are classified correctly and none of the brain damaged subjects are misclassified as schizophrenics. The findings lend additional support for Hypothesis six, that a subgroup of the schizophrenic group showing lateralized sensory integration dysfunction would perform similarly to one of the three brain damaged subgroups.

A factor analysis on the HVDT subtests performed by McCarron and Dial (1979) found that for normal subjects, two factors emerged: one loaded by size and texture; the other loaded by shape and configuration. A post hoc factor analysis of the HVDT subtest scores was undertaken. The resulting factor structure for the diffuse brain damaged group is similar to the factor structure for normals identified by McCarron and Dial. The factor structure for the schizophrenic group in the present study reveals one factor is loaded by right hand size and texture and right and left hand configuration. The second factor is loaded by right and left hand shape. In analyzing the factor analysis data, the normal and diffuse brain damaged groups appear to process sensory information qualitatively the same but quantitatively different. HVDT subtest scores for the diffuse brain damaged group is just lower than scores for normal subjects. It is believed that the schizophrenic group appears to qualitatively process sensory integration differently than both normals and diffuse brain damaged subjects but quantitatively the schizophrenic group is more similar to normals than is the diffuse brain damaged group.

There are several possible explanations to partially explain the findings in the present study. One explanation is that the HVDT is not an instrument that has been used before in studying differential diagnosis between schizophrenia and brain damage. The test may be more sensitive to certain areas of sensory integration functioning and may be more effective in measuring dysfunction. Another explanation for the results may be the way that clients were selected. For the schizophrenic group, two independent psychiatric diagnoses and a review of the history may be partially responsible in ruling out brain damage in a schizophrenic subject and thus represent an artifact rather than a true finding. For future studies it appears that evaluations to rule out brain damage should involve more sophisticated techniques such as the PET scan or CAT scan rather than relying upon soft neurological signs. Also in future research, the anterior portions of the cortex which mediate cognitive functions should be examined more in depth, in combination with sensory integration for a more comprehensive understanding between schizophrenic and brain damaged populations. Another explanation is that the observed dysfunction in schizophrenic subjects may not be a true neurological dysfunction but may be nothing more than learned behavior.

One of the main issues in the literature has been one of differential diagnosis between schizophrenic and brain damaged subjects. The issue may be easily confused as the data suggests that there are subgroups of schizophrenia that not only perform as do brain damaged subjects but may in fact be brain damaged. Psychologists usually assess performance levels as measured by I.Q., and level of the MMPI during diagnostic testing. Psychologists usually do not assess neuropsychological functions, comparing the two sides of the body for differential diagnoses. The findings in the present study suggest that there may be some asymmetrical differences between brain damaged and schizophrenic subjects. The asymmetry of the body, hemisphere functioning and performance all need to be assessed for more accurate diagnosis. The study reveals that testing just sensory integration is not sufficient for accurate differential diagnosis. The study does suggest however, that an analysis of sensory integration and lateralizing functions is necessary for a comprehensive assessment of an individual. When the diagnostic question involves differentiating between schizophrenic and brain damaged subjects, tests which assess cognitive functions, personality characteristics, sensory functions, and fine and gross motor functions may be neccessary.

Hypotheses concerning treatment plans are generated from diagnostic evaluations. Treatment plans involve an attempt to restore or recover certain functions (cognitive, perceptual, sensory, and motor). Treatment plans also involve implementation of certain strategies to by-pass problems or dysfunctions which cannot be readily restored. The present study examines a certain area of functioning in schizophrenics which is not generally tested in psychological evaluations. The findings suggest the need for more comprehensive testing in the area of neuropsychology to better ascertain skill assets and deficits in schizophrenics for differential diagnosis and treatment planning. The question of schizophrenia involving brain damage may no longer be valid. There are certain subgroups of schizophrenia that do involve brain dysfunction and damage. Future research may want to focus on brain-behavior relationships seen in certain types of mental disorders in order to have a comprehensive understanding of the disorders and the obvious implications for diagnosis and treatment considerations.

In the study, the schizophrenic group shows neuropsychological deficits in sensory integration when compared to normals. The schizophrenics's deficits are less pronounced than a group of patients with known brain damage. Findings suggest some lateralized dysfunction in the schizophrenic group in the right hemisphere parietal-occipital lobes. Multiple discriminant analyses are used in the study to discriminate between schizophenic subjects and subjects with right hemisphere, left hemisphere, and diffuse brain damage. Multiple discriminant analyses are less accurate on cross validation than other types of analyses. The functions generated by the analyses need to be tested against random samples using schizophrenic and brain damaged subjects in order to generalize the findings. Hit rates also should be compared in cross validation studies. The Bender Gestalt, which measures sensory motor integration, and HVDT, a measure of sensory integration, can differentiate between the schizophrenic and the brain damaged groups. The size subtest, the most complex of the HVDT subtests is best at differentiating between the two groups. Although the hit rates are statistically significant, a clinician would not want to make a diagnosis based only on the test scores used in this study. Analyses indicate dysfunction in the right parietal-occipital lobes for some schizophrenic subjects. The level and pattern analyses indicate that the schizophrenic group qualitatively process information differently than do the brain damaged subgroups. In enhancing differential diagnosis between schizophrenics and brain damaged subjects there is a need to assess both overall performance and lateralization functions of the hemisphere. The definition of neuropsychology is the study of brain mechanisms underlying behavior and the clinical application of known brain-behavior relationships to the evaluation and treatment of patients with known or suspected brain damage and/or dysfunction. A neuropsychological approach is desired for not only enhanced differential diagnosis among schizophrenic and brain damaged populations, but also for comprehensive treatment planning for both groups.

Appendix A

Embree/Butler's Bender Scoring Sheet

Name______________________

Date tested________________

<u>Error Scores</u>	<u>1st</u>
<u>5 points</u>	
Partial rotation (A, 4, 5, 6, 7, 8)	____
Omission of angles (A, 4, 7, 8)	____
<u>4 points</u>	
Added angles (A, 4, 7, 8)	____
Overlap difficulty (7)	____
Distortion (all)	____
Tremor (all)	____
<u>3 points</u>	
Embellishments (A, 4, 6, 7, 8)	____
Lack of Closure (A, 4, 7, 8)	____
Angles Flattening (3)	____
Total	____

Appendix A--Continued

Scoring Instructions

Each of the weighted signs is only scored once per record. For example, a Partial Rotation might occur on Designs A, 4, and 7 on one record, but the maximum number of points scored for partial rotations would be five points. When a sign is noted on any of the designs indicated, the weight given on the Score Sheet is recorded in the blank space. The sum of all weighted scores recorded is the Total Score.

Scoring Criteria

1. Partial Rotation (Designs A, 4, 5, 6, 7, 8):

   When only one subpart of the design is rotated 21 degrees or more. Card or paper rotations of the whole, but correctly reproduced, design do not score.

2. Ommision of Angles (Designs A, 4, 7, 8):

   An angle is omitted.

3. Added Angles (Designs A, 4, 7, 8):

   An extra angle is added. Lines forming the extra angle should be approximately straight and form a definite angle. Dog-ears do score. Curves or arcs caused by a change in direction of a line do not score. A jagged line which results from a gross tremor does not score.

4. Overlap Difficulty (Design 7):

   Difficulty in reproducing the overlapping angles on Design 7.

5. Distortion (All Designs):

   Reproduction exhibits a basic destruction of the gestalt of the design although all of the separate elements may be present.

6. Tremor (All Designs):

   Noticeable fine or gross waviness is evident in reproduction of lines.

Appendix A--Continued

7. Embellishments (Designs A, 4, 6, 7, 8):

   An extra meaningless line is included in the design. Extra lines that are not integrated into a design are scored. Such lines are usually in an opposite direction from the lines to which they are near or attached. These are often small and lightly drawn and are easily overlooked in scoring.

8. Lack of Closure (Designs A, 4, 7, 8):

   Any one design has two or more angles which are not closed.

9. Angle Flattening (Design 3):

   Angled dots are flattened to the extent that no angle or apex of angle is evident.

Appendix B

Name______________________ Rater____________________

SYMPTOM RATING SCALE

AUTISM

1 2 3 4 5

AMBIVALENCE

1 2 3 4 5

AFFECT

1 2 3 4 5

THOUGHT PROCESS

1 2 3 4 5

PARANOIA

1 2 3 4 5

Appendix C

INFORMED CONSENT

I, ______________________________ DO HEREBY CONSENT to participate in an investigation of the ability to see and feel objects conducted by Ann Wigodsky or her representative. I understand that I will be asked to feel different objects and pick them out from pictures. This will be done with both hands. It will require about one hour.

I have heard a clear explanation and understand the nature and purpose of this study.

I understand that my name will not be used on any of the findings or reports from this study, and that test materials remain confidential. There is no risk involved during my participation in this investigation.

I understand that the procedure to be performed is research in nature. This consent to particiapte will expire in 30 days or anytime before that I wish to withdraw. I understand that my participation in or withdrawal from this study will not affect services offered me.

With my understanding of this information, I voluntarily consent to the procedure stated above.

Appendix C--Continued

Signature	Date
Witnessed	Date

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