THE ASSESSMENT OF COGNITIVE FUNCTIONING OF PERSONS WITH SCHIZOPHRENIA: IDENTIFICATION OF NEUROPSYCHOLOGICAL MARKERS

DISSERTATION

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

DOCTOR OF PHILOSOPHY

By

Janice Anne Crawford Hall, B.S., M.M.F.T., M.S.
Denton, Texas
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Prior research has shown that persons with schizophrenia have impaired cognitive functions that continue years after the acute phase. These deficits affect functional abilities and overall quality of life. While some evidence points to impairment with executive, language, and memory functions, conclusions have been mixed as to the exact nature of these impairments. The present study was conducted to clarify and expand knowledge of cognitive functioning in chronic schizophrenia patients (N=21) as compared to a bipolar group (N=20) and a normal group (N=20).

To examine cognitive functioning, the three groups were administered neuropsychological tests, including the Wisconsin Card Sorting Test (WCST), Trail Making Test (Trails), Controlled Oral Word Association (COWA), Stroop Color and Word Test, California Verbal Learning Test (CVLT), Wechsler Memory Scale-Revised (WMS-R), Rey-Osterrieth Complex Figure (Rey), and Kaufman Brief Intelligence Test (K-BIT). Results of a MANOVA indicated that there were significant differences among the three research groups. Results of a MANCOVA, with education and intellectual level as covariates, continued to demonstrate significant differences among the three groups in all but the Stroop Interference task. Neuman-Keuls follow-
up analyses indicated the schizophrenia group was significantly different from the normal group on all the neuropsychological variables measured (WCST Categories, WCST Perseverative Errors, Trails B Time T Score, Controlled Oral Word Association Total, Stroop Interference T Score, CVLT delayed free recall, Rey delayed memory, WMS-R logical stories delayed memory). However, no significant differences were found between the schizophrenia and bipolar groups on the Stroop Interference T Score, WMS-R logical stories delayed percentile, and the Rey Figure delayed memory raw score. These results provide continued support of cognitive dysfunction in schizophrenia, specifically impairment in changing cognitive sets, mental flexibility, verbal fluency, and delayed verbal and figural memory. These results also point to frontal and temporal lobe dysfunction in schizophrenia patients.
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CHAPTER I

INTRODUCTION

Although schizophrenia has been examined for many years with mixed conclusions, converging research points to neuropsychological assessment as an important component in understanding cognitive functioning over the course of the illness. Beyond the identification of symptoms, the ability to assess and identify cognitive patterns common to schizophrenia in its various stages will provide a knowledge base to enhance the rehabilitation program.

Schizophrenia is a complex disorder. Understanding schizophrenia necessitates a multifaceted approach, including physiological, neuropsychological, and social analyses. The purpose of this study is to delineate patterns of cognitive abilities and dysfunction specific to schizophrenia. Brain-behavior relationships will be explored. The goal of this research is to explore neurobehavioral patterns such that their delineation will aid in the psychological assessment and treatment planning of individuals with schizophrenia.

A Theoretical Base

Alexander R. Luria, a Russian neuropsychologist, developed a theory of neuropsychological organization (Luria, 1973). This theoretical orientation evolved out of Luria's clinical work in
neuropsychology. According to the theory, the brain is organized into functional units that inter-relate in a dynamic system (Languis & Miller, 1992; Naglieri & Das, 1990; Sohlberg & Mateer, 1989). The three major functional units include the arousal unit, the sensory input unit, and the planning and output unit. While each functional unit is associated with specific anatomical structures, the brain is perceived as a whole with interdependent structures and functional systems.

The first functional unit, the arousal unit, is composed of the upper brainstem and the limbic system (Begali, 1987; Golden, 1984). Luria suggested the reticular activating system plays an important role in the attention and regulation of stimuli to the cerebral cortex. The ascending reticular system involves the brainstem, through the diencephalon and up to the limbic system; the descending reticular system then goes from the frontal cortex back to the brain stem. Disruption of this system results in loss of cortical tone, affecting attention and arousal. Thus, dysfunction with this energy source would reduce alertness and the accurate perception of the incoming stimuli (Reitan & Wolfson, 1988).

Luria's second functional unit is responsible for sensory input, analysis, and integration of information (Golden, 1984). This theory focuses on higher level processing. The focus includes the primary sensory areas, where incoming stimuli are encoded; the secondary areas, where information is organized and integrated within each modality; and tertiary areas, where information is synthesized and integrated between modalities. This functional unit is associated with
the posterior regions of the brain such as the temporal, parietal, and occipital lobes.

The third unit involves executive functions, including planning and output (Naglieri & Das, 1990). Behavioral responses are thought to involve the anterior frontal areas of the brain. The primary areas are responsible for modality specific motor output; the secondary areas are responsible for organizing and smoothing out behavioral output; and the tertiary areas, prefrontal cortex, involve planning and evaluating voluntary behavior. The planning and output functions involve anterior brain regions. Each of these three functions has a specific role and yet, coordinates with the other functions.

Luria's theory suggests a developmental-neuropsychological model. (Begali, 1987; Golden, 1984; Hynd & Willis, 1988; Naglieri & Das, 1990). The brain’s functions develop according to stages, beginning with the arousal mechanisms; the reticular system is usually functioning at birth with full development within 12 months after conception. The second stage involves the development of the primary motor and sensory areas. The secondary motor and sensory areas are developed during stage three, from conception through age five. The hemispheres tend to specialize in either verbal or nonverbal processing, with over 90% of children having left hemispheres that specialize in verbal functions by age two. The tertiary areas begin to develop between ages of five and twelve, thus comprising the fourth stage. The final stage of development involves the tertiary areas of the frontal lobes. This fifth stage typically begins in early adolescence and continues to develop for some until
early adulthood. Luria’s theory provides a base for evaluating the cognitive functions of schizophrenia.

A Neurodevelopmental Model

Although various theories and models have been proposed to explain schizophrenia, three consistent facts tend to support a neurodevelopmental model (Weinberger, 1987). First, clinical findings suggest initial symptoms usually appear in late adolescence or early adulthood. Second, stress appears related to the onset of symptoms and relapse. Third, neuroleptic drugs are of therapeutic value.

The neurodevelopmental model, as defined by Weinberger (1987), suggests that the person with schizophrenia has a brain lesion which occurs early in the developmental process. As the brain matures, the effects of the lesion interact with normal developmental processes. According to this model, the age of the brain influences the cognitive manifestations of the lesion. This type of development is similar to examples of childhood brain trauma. In that situation, the child manifests with different symptoms as the brain develops and encounters environmental stress (i.e. entering school). Thus, the effects of some lesions may not become apparent until the brain functionally matures.

In schizophrenia, a lesion affecting a specific part of the neural system may produce no symptoms until the person reaches a vulnerable period of late adolescence/early adulthood. The dorsolateral prefrontal cortex (DLPFC) is an area in both animal and human brains that reaches functional maturity in early adulthood (Weinberger, 1987). The cognitive dysfunction of schizophrenia has
also been associated with this area of the brain. For example, one function of the DLPFC is the ability to evaluate and determine choices of future behavior based on prior experience. Developmental research suggests that these types of cognitions are not prevalent prior to adolescence. The Wisconsin Card Sorting Test is sensitive to the cognitive functions of the DLPFC. This test is difficult for children but performance improves in adolescence. Thus, a lesion in the DLPFC might be unremarkable during childhood, becoming more prevalent in late adolescence.

In support of the neurodevelopmental model, research shows an adequate level of the neurotransmitter dopamine is needed for normal functioning of the prefrontal cortex (Weinberger, 1987). Some research suggests that maximum dopaminergic activity occurs in early adulthood. A lesion in the prefrontal cortex will affect feedback to the dopamine system.

Therefore, late adolescence/young adulthood appears to be a critical time. The young adult is gaining independence and dealing with the challenges and stress of change and decision making. The prefrontal cortex is continuing to develop which aids in the cognitive processes important for healthy individuation. The dopamine systems are functioning at a high level during this time. The neurodevelopmental model suggests that a young adult with an impaired prefrontal cortex, a very active dopamine system which is receiving impaired feedback from the DLPFC, and a demanding environment which needs the cognitive functions of the DLPFC, may begin producing symptoms characteristic of schizophrenia. This
model provides a framework for understanding some of the cognitive dysfunctions of schizophrenia.

A Connectionist Framework

A growing body of evidence supports the influences of structural and regional brain abnormalities, neurotransmitter dysfunctions i.e. dopamine and norepinephrine, and cognitive/behavioral deficits. The neurodevelopmental model aids understanding of how these components mesh to create the symptoms of schizophrenia. Luria's theory provides an understanding of cognitive processing. In accord with both of these, the connectionist framework connects information-processing deficits with biological disturbances in schizophrenia (Cohen & Servan-Schreiber, 1992).

The connectionist model suggests that schizophrenia patients have difficulty producing and maintaining an internal representation of context which influences their ability to make appropriate responses. Cohen & Servan-Schreiber (1992) suggest that the prefrontal cortex is influential in developing and maintaining appropriate cognitive sets. Also, the neurotransmitter dopamine is needed for healthy functioning of the prefrontal cortex. In schizophrenia, both the prefrontal cortex and the dopamine system appear to be abnormal. These abnormalities create disturbances in the person's ability to utilize contextual information, thus the inability to develop and shift cognitive sets. Although this model limits itself to the frontal and dopamine systems, the researchers suggest that it
might be extended to other abnormal brain regions, such as the temporal lobes, which appear to influence schizophrenia.

Neuropsychological Assessment

The neuropsychological assessment provides an evaluation of a person's abilities and deficits in specific areas of cognitive functioning (Benton, 1991; Lezak, 1983). The assessment may include intellectual abilities, memory functions, orientation and attention, motor skills, and linguistic, perceptual, and constructional functions. The test procedures are an objective refinement of clinical observation. Many of these tests are designed to determine the level at which a person performs. Thus, the cognitive/behavioral consequences of persons with psychiatric impairment can be measured to determine current level of functioning.

The heterogeneous nature of schizophrenia creates difficulties in assessment, treatment, and the development of a consistent knowledge base (Goldstein, 1991; Heinrichs, 1993). For example, the Halstead-Reitan Neuropsychological Test Battery (Reitan & Wolfson, 1993) and the Luria-Nebraska Neuropsychological Test Battery (Golden, Hammeke, & Purisch, 1980; Levin, Yurgelun-Todd, & Craft, 1989) are helpful in distinguishing brain damaged patients and schizophrenia patients, with the latter obtaining lower global scores. Although persons with schizophrenia tend to fall within the impaired range on these batteries, the research is controversial as to whether these two batteries delineate patterns of dysfunction specific to schizophrenia. However, some research suggests that more specific tests of neuropsychological functioning may help delineate certain
patterns of cognitive deficits in schizophrenia, especially tests involving frontal lobe and temporal lobe and lateralized functions. In the current study, neuropsychological assessment is utilized to increase knowledge of organizational brain activity and its application to cognitive/behavioral functioning as it relates to persons with schizophrenia. Thus, the findings of the proposed study may benefit both diagnosis and treatment planning in rehabilitation of patients.

Negative versus Positive Symptoms

Schizophrenia is characterized by the development of positive and negative symptoms throughout its course. Positive symptoms include new behavioral manifestations atypical for normal individuals, i.e. delusions, hallucinations, bizarre behaviors, thinking disorders. Negative symptoms involve the lack of behaviors expected in normal functioning such as blunted affect, lack of interest in relationships, inattentiveness, poverty of speech, blocking, delayed response, lack of attention to grooming and hygiene, and formal thought disorder. Research has inconsistent definitions and inconsistent findings with regard to the exact nature of these two constructs (Cromwell, 1993; Rubin & Harrow, 1993). However, while still needing validation, these constructs help to provide an understanding as to the course and the cognitive dysfunction of schizophrenia.

Cromwell (1993) integrates research on positive and negative schizophrenia to give an overview of the course of the disorder. During the premorbid period, negative symptoms begin to appear and may be maintained even when psychosis becomes apparent. The
acute phase is marked by the emergence of the positive symptoms; both positive and negative symptoms may increase. Following the acute phase, positive symptoms may lesson or become episodic; over 50% of patients will continue to experience some positive symptoms during the course of illness. Hallucinations are the most stable of the positive symptoms. Positive symptoms will tend to occur intermittently, usually signifying a relapse episode, while negative symptoms tend to endure. The negative symptoms have both trait and state qualities, increasing during acute phases then enduring at a less intense level. When the patient is post acute, the negative symptoms then become the best index of severity. The most prevalent negative symptom is concrete thinking. Cromwell concludes that positive and negative symptoms tend to develop separately throughout this disorder. Thus, they are the manifestations of different cognitive processes and may arise from different etiological factors.

Researchers have debated the course of schizophrenia and its influence on cognitive functioning (Goldberg, Hyde, Kleinmen, & Weinberger, 1993). According to one view, cognitive dysfunction is exacerbated during the acute phase but then progressively declines. Intellectual, memory, and social functioning become more impaired. The second view perceives cognitive functioning as becoming impaired, then stabilizing, although still dysfunctional. These researchers reviewed longitudinal, cross-sectional, and correlational studies that examined the relationship between cognitive functions and duration of schizophrenia. The cognitive studies did not support
the view of progressive deterioration of cognitive functions. However, research does provide evidence for an initial drop in cognitive function followed by a period of stabilization of deficits. Knowledge of cognitive deficits and their chronicity patterns has implications in developing long term treatment strategies for patients.

In a study of 101 male chronic, schizophrenia patients, length of hospitalization was significantly related with negative symptomatology (Raskin, Pelchat, Sood, Alphs, & Levine, 1993). As age and hospital stay increased, so did presence and severity of restricted affect, emotion perception deficits, speech retardation, poor speech quality and poor hygiene. The researchers were inconclusive as to whether this finding was influenced by the disease process, neurochemistry, long periods of institutionalization, or long term neuroleptic use. The findings are important in the development of inpatient rehabilitation programs over the course of schizophrenia.

Structural/Anatomical Differences

Anatomical abnormalities serve as markers for cognitive dysfunction in persons with schizophrenia. In a review of 50 neuroanatomical postmortem studies, Bogerts (1993) concluded that various anatomical structures appear to be related to schizophrenia. Data on brain weight and size are inconclusive since earlier studies were poorly controlled. Several recent studies with better controls site significant differences in brain weight; brains of schizophrenia patients weighed 5%-8% less than those of non-schizophrenia subjects. Also, one study found a significant reduction by 4% in brain
size of schizophrenia patients compared to non-schizophrenia subjects.

In a review of the literature, Crow (1990) cites evidence for asymmetrical brain structure in schizophrenia. Research techniques included air encephalography, computed tomography, magnetic resonance imaging, and post-mortem examinations. Findings indicate that schizophrenia is significantly correlated with left sided structural differences. In several studies, ventricular enlargement, particularly on the left side, is reported. The ventricular size appears to be greater in chronic versus acute cases.

Although inconsistencies exist, overall research suggests that the negative symptoms of schizophrenia (flattened affect, poverty of speech, apathy, anhedonia, low social interest, and attentional difficulties) are correlated with large ventricular-brain ratios (Grove, & Andreasen, 1991; Andreasen, Flaum, Swayze, Tyrrell, & Arndt, 1990). Positive symptoms (hallucinations, delusions, bizarre behavior, and catatonic behaviors) are associated with small ventricular-brain ratios, as reported by Grove and Andreasen (1991).

Specific brain regions have received attention in exploring neuroanatomical differences. A few studies implicate the frontal cortex, although analysis is complicated due to the heterogeneity of the frontal lobe (Gur & Pearlson, 1993). Two studies found decreased brain volume or area of the frontal region, as discussed by Gur and Pearlson. In a postmortem enzyme study of patients with schizophrenia, results suggest an abnormal distribution of neurons in
the prefrontal cortex (Akbarian, Bunney, Potkin, Wigal, Hagman, Sandman, & Jones, 1993). The researchers suggest that this neuronal abnormality is consistent with a disruption of normal development, perhaps in the second trimester of pregnancy when neurons are changing position and forming necessary cortical connections. A disruption would thus impede the formation of normal connections. The disruption would become apparent when these cortical connections reach functional maturity i.e. adolescence.

Abnormalities of the temporal lobes have been reported. The left temporal lobe area was smaller in size when compared to normal controls and affective patients (Crow, 1990). Also, one study showed that the left temporal horn is enlarged in schizophrenia, differentiating it from Alzheimer-type dementia where both sides are enlarged. Crow concludes that genetic components influence the development of the left sided structural differences in schizophrenia.

In an MRI study of 17 patients with schizophrenia and 17 normal subjects, the volume of temporal lobe gray matter was 20% smaller in the schizophrenia patients (Suddath, Casanoma, Goldberg, Daniel, Kelsoe, & Weinberger, 1989). An enzyme study, used to identify the presence or absence of neurons, concurs with anatomical differences in the temporal lobe and parts of the hippocampus (Akbarian, Vinuela, Kim, Potkin, Bunney, & Jones, 1993).

Research findings about anatomical abnormalities in the basal ganglia are inconsistent (Gur & Pearlson, 1993). Some studies report no differences in volume while others report an increase in volume of
the lenticular nucleus (globus pallidus and putamen). Another study found that male schizophrenia patients had an enlarged putamen.

In support of structural differences, a comparison of postmortem brain structures showed significant differences between patients diagnosed with schizophrenia and a primary affective disorder, including bipolar disorder (Brown, Cloter, Corsellis, Crow, Frith, Jagoe, Johnstone, & Marsh, 1986). Schizophrenia patients had lighter fixed brain weight which was not significantly influence by differences in body weight or height. Patients with schizophrenia had larger lateral ventricles than the affective patients, although this became nonsignificant when the patients with manic episodes were excluded from the affective group. Also, the results suggest structural changes in the temporal lobe area, with a larger temporal horn area (by 97%) and a reduced parahippocampal cortical thickness for the schizophrenia group.

Although findings continue to be discrepant, these differences may reflect the heterogeneity of the illness. Most of the anatomical studies appear to lend support to a disorder of brain development (Bogerts, 1993). The knowledge of anatomical abnormalities in schizophrenia has given insight into regions of brain dysfunction and neurocognitive deficits.

Regional Brain Function

As suggested by Luria's theory, anatomical abnormalities appear to inter-relate with brain functions. Computer-assisted imaging, as well as other clinical techniques, have helped to identify these associations. Integration of studies using positron emission
tomography (PET) find the frontal lobes, basal ganglia, and temporal lobes related to schizophrenia (Buchsbaum, 1990). Low metabolic rates were observed in all three areas. Also, these three areas correlated highly with each other. The frontal lobes, basal ganglia, and temporal lobes did not significantly add to the prediction of a schizophrenia diagnosis after any one of these areas was already used in a prediction equation. Thus, rather than three distinct entities or three different types of schizophrenia, the researcher suggests dysfunction of the fronto-striatal-temporal system as influencing schizophrenia.

Functional changes in the frontal lobes have been examined (Gur & Pearlson, 1993). Persons with schizophrenia appear to have decreased cerebral blood flow (rCBF) and decreased metabolic activity in the frontal lobes relative to normal persons. In a study of rCBF and symptom profiles, three syndromes were delineated as a result of factor analysis including psychomotor poverty, disorganization, and reality distortion (Liddle, Friston, Frith, Hirsch, Jones, & Frackowiak, 1992). Psychomotor poverty was associated with the left prefrontal cortex, although the authors concur that the laterality effect was one of degree since qualitatively similar patterns were seen on the right. The right prefrontal cortex was related to the disorganization syndrome. While the majority of frontal abnormalities were on the right for the disorganization syndrome, there was evidence of some abnormality of Broca's area. These findings suggest that speech production (Broca's area) and the disorganization syndrome, a feature of a formal thought disorder, are related in schizophrenia. Also, both
hemispheres of the parietal association cortex appear associated with the disorganization syndrome. The reality distortion syndrome was associated with dysfunction of the left temporal lobe.

Research consistently identifies abnormalities of the medial temporal lobe in most schizophrenia patients (Roberts, 1991). This area is crucial in integrating and processing input received from the association cortex. Developmentally, the temporal lobe develops from week 31 of pregnancy to term, with the left temporal lobe developing slightly later than the right. Thus, an aberration, affecting both hemispheres during this period, would tend to affect the left more than the right.

In a review of studies involving the relationship between positive and negative symptoms, researchers consistently found a significant relationship between left temporo-limbic dysfunction and positive symptoms (Bogerts, Falkai, Degweer, & Lieberman, 1991). Negative symptoms are more difficult to localize with most findings consistent with diffuse damage.

Other research supports differences in regional brain functioning. A study of magnetic resonance relaxation time showed significant differences between schizophrenic patients and normal controls (Williamson, Pelz, Merskey, Morrison, Karlik, Drost, Carr, & Conlin, 1992). Specifically, the left frontal white matter, left temporal cortex, left temporal white matter, and left lenticular nuclei (basal ganglia) were abnormal.

Functions of the frontal and temporal lobes have been associated with difficulties in social communication by persons with
schizophrenia (Deakin, 1994). In post-mortem studies, biochemical abnormalities have been found in the frontal and temporal lobes of persons with schizophrenia. Findings suggest that the temporal cortex is involved with processing speech and nonverbal communication, i.e. facial expressions and hand gestures. The frontal cortex is associated with the integration of expressive motoric communication. Thus, in schizophrenia, temporal lobe dysfunction might be manifested in impaired ability to comprehend social cues, while frontal lobe impairment might lead to poverty of speech, lack of emotional expressiveness, abnormal posturing and facial gestures.

Although difficult to measure, some researchers suggest the need to understand the connections between cortical and subcortical functions as related to schizophrenia (Crosson & Hughes, 1987). Specifically, these researchers focus on the thalamus as link between the frontal cortex and the basal ganglia. The nucleus accumbens is connected with the limbic system and has output to the globus pallidus. The globus pallidus has outputs to the ventral anterior thalamus which then connects with the dorsolateral prefrontal cortex. Crosson and Hughes (1987) suggest that the ventral anterior nucleus of the thalamus helps to regulate meaningful language. These researchers hypothesize that dysfunction with this system leads to problems with language formulation and production as found in schizophrenia.

While assessment techniques have improved, findings are still inconsistent. Most research appears to point to some types of abnormalities in the basal ganglia, frontal, and temporal lobes. The
most consistent finding is left temporal lobe dysfunction, while
damage to the right hemisphere appears more diffuse.

Neurobehavioral Correlations

Neuropsychological research, like regional brain functions and
anatomical studies, implicates several of the same regions in
influencing schizophrenia processes. These regions include the frontal
and temporal lobes, and basal ganglia (Buchsbaum, 1990). The frontal
lobes involve abstract thinking, executive functioning, and possibly
some types of attention. The prefrontal cortex, located in the anterior
portions of the frontal lobes, integrates incoming information from
both internal and external sources and then helps to determine a
response (Lezak, 1983). The basal ganglia is rich in the
neurotransmitter dopamine, and contributes to motor programming.
The temporal lobe plays a role in auditory processing, language
function, and delayed memory. While the research reviewed
implicates different cerebral areas, schizophrenia may be thought of
as distinct types/subtypes involving separate areas of the brain, or it
may be seen as a dysfunctional system involving cortical and
subcortical interconnections.

Research has compared patients with focal lesions in the frontal
lobe to patients with schizophrenia. One of the primary measures
used for analysis is the Wisconsin Card Sorting Test (WCST, Heaten,
1981). In a review of studies using the WCST, the performance of
frontal lobe patients was worse, i.e. fewer categories achieved and
more perseverative errors, than patients with focal damage in other
areas of the brain and normals (Van der Does & Van den Bosch, 1992).
However, the WCST, did not significantly differentiate between frontal and diffuse damage. The researchers noted one study where the performance of patients with temporal lobe epilepsy on the WCST was similar to frontal lobe patients. After analysis, the study of patients with epilepsy concluded that the temporal lobe was not essential to effective WCST performance. Also, Van der Does and Van den Bosch note that right frontal patients made fewer total errors and obtained more categories but probably had a higher proportional perseverative error score than left frontal patients.

While most research supports the association between frontal lobe function and performance on the Wisconsin Card Sorting Test, some findings are discrepant. One study compared subjects with stable focal frontal lesions and subjects with nonfrontal lesions on the WCST (Anderson, Damasio, Jones, & Tranel, 1991). No significant differences were found between the two groups. These researchers concluded that the WCST cannot be used in isolation to predict frontal lobe dysfunction. One explanation for the differences in findings may be because the frontal lobe subjects were chronic. Thus, these patients may have developed compensatory strategies which improved their performance.

Schizophrenia subjects have shown significant impairment on most studies involving executive functions. A study by Weinberger, Berman, and Zee (1986), in which regional cerebral blood flow (rCBF) of 20 medication-free subjects with chronic schizophrenia and 25 normal control subjects was measured, provides support for dysfunction of the dorsolateral prefrontal cortex in schizophrenia.
The patients had no significant increase in rCBF in the DLPFC compared to normals while performing the Wisconsin Card Sort Test (WCST). No significant differences were noted between the two groups when comparing whole brain flow for both resting and activated conditions. In the patient group, the DLPFC rCBF and the WCST had a significant positive correlation, suggesting the more activated the DLPFC than the better the performance and vice versa.

In a follow up study, Weinberger, Berman, & Illowsky (1988) confirmed earlier findings of dorsolateral prefrontal cortex involvement during performance on the WCST. Sixteen subjects with schizophrenia showed no significant increase in the DLPFC rCBF as compared to the increase in normal control group. Thus, these studies suggest metabolic hypofrontality in patients with schizophrenia.

Research on monozygotic twins discordant for schizophrenia found neurocognitive and neurobiological differences (Weinberger, Berman, Suddath, & Torrey, 1992). The identical twins performed the WCST while undergoing magnetic resonance imaging (MRI) and assessment of regional cerebral blood flow (rCBF). Results suggest that the affected twin had an abnormality of the hippocampus which was related to an abnormality of the prefrontal cortex during a cognitive task, which required executive functions. These findings suggest a neural network that communicates and affects specific cognitive functions such as the ability to generate and change cognitive sets.

Other findings suggest differences in neuropsychological performance in schizophrenia on tests measuring frontal lobe
function. One study of ten medication free and 20 medicated patients, and 30 subjects in a normal control group demonstrated that schizophrenia patients (especially the medication free group) performed worse on measures of frontal lobe functioning, including the WCST and the Chicago Word Fluency Test, also called Controlled Oral Word Association Test (Morrison-Stewart, Williamson, Corning, Kutcher, Snow, & Merskey, 1992). While scores on the Design Fluency test were within the impaired range for subjects with schizophrenia, no significant difference was found when compared to the control group. The WCST and Chicago Word Fluency tests appear more sensitive to left frontal dysfunction while the Design Fluency test appears to be sensitive to right frontal dysfunction. These researchers conclude that patient groups had more difficulty with tests requiring cognitive flexibility, especially when using verbal material. These results suggest left frontal cortex deficits.

However, some findings are inconsistent with regards to schizophrenia patients' performance on frontal lobe measures, specifically the Wisconsin Card Sorting Test. One study found significant differences between the schizophrenia group and the normal control group on number of correct responses and perseverative errors but no significant differences between the performance of the schizophrenica group, a mood disorder group and a head injured group (Axelrod, Goldman, Tomkins, & Jiron, 1994). These results suggest that the Wisconsin Card Sorting Test may not always be helpful in discriminating between patient groups. However, the mood disorder group consisted of both unipolar and
bipolar patients and their was no specific description regarding type of brain injury. Thus, the mixed and nonspecific criteria for the comparison patient groups may have confounded results.

Some research suggests that patients with schizophrenia have difficulty generating and shifting cognitive sets but are able to maintain a response set once established (Goldman, Axelrod, & Tompkins, 1992). In a study comparing 24 inpatients with schizophrenia with 24 inpatients with affective disorders, the patients with schizophrenia had more difficulty formulating and shifting cognitive sets than the individuals with affective disorders. However, both groups improved performance when given cues prior to beginning the task. Both groups maintained a cognitive set, regardless of whether cued. These researchers conclude that the frontal lobe dysfunction in schizophrenia may lie in the generation of accurate cognitive schemas rather than their implementation. Thus, once provided with an accurate cognitive set, the individual with schizophrenia could maintain performance.

Cognitive verbal flexibility, associated with frontal lobe functions, was differentiated from verbal intellectual functions (Crawford, Obonsawin, & Bremner, 1993). Forty-eight schizophrenia patients were compared with normal controls, matched for age, sex, and education. Also, an additional sample of 144 control subjects was tested. All subjects were given a verbal fluency test (Controlled Oral Word Association) and verbal intellectual assessment (Wechsler Adult Intelligence Scale - Verbal Scale). Performance on both these tests was significantly lower for the schizophrenia patients. In an analysis
to predict verbal fluency from verbal intellectual functioning, schizophrenia subjects performed significantly lower on verbal fluency than would be expected given their verbal intelligence. Thus, cognitive flexibility dysfunction can not be entirely explained by intellectual level, lending further support for specific frontal involvement in schizophrenia. These researchers note that the schizophrenia subjects differ from subjects in a previous study with focal frontal lesions and with Alzheimer's dementia on these tasks (Miller, 1984). In contrast to focal frontal patients, verbal intelligence was also impaired in the schizophrenia patients. In schizophrenia, intellectual level does not fully account for the severity of verbal fluency dysfunction as in Alzheimer patients.

Representational/working memory was impaired in medicated schizophrenia subjects relative to bipolar psychiatric patients and normal control groups (Park & Holzman, 1992). In this study of 36 subjects (12 per group), the spatial memory task required subjects to make an internal representation of a target and then subsequently use it to determine a response. The schizophrenia group was significantly impaired on both the oculomotor and haptic memory tasks. No significant impairment was noted during the oculomotor nor haptic sensory-guided tasks. Thus, the dysfunction occurred with representational memory rather than simple eye or hand motor movements. These researchers suggest that the deficit in representational memory is correlated with prefrontal dysfunction, similar to the impaired performances found in animals and in humans with prefrontal lesions.
Researchers have continued to provide evidence for generalized neuropsychological impairment in schizophrenia as well as a verbal, semantic memory and learning deficit (Saykin, Gur, Gur, Mozley, Mozley, Resnick, Kester, & Stafiniak, 1991). Also, visual memory of 36 unmedicated schizophrenia patients was significantly impaired compared to 36 normal controls. However, this study found only minor impairment of abstraction-flexibility abilities, as measured by the WCST, and motor abilities. Auditory processing and attention were mildly impaired while visual-motor processing and attention were not significantly different from controls. Also, spatial organization and language (i.e. word association and recognition, sentence repetition, and comprehension tests) skills were not significantly impaired. These findings provide support for left temporal involvement.

Neurobehavioral tests suggest both frontal and temporal involvement. In a study of 36 patients with schizophrenia and 36 normal controls, the patients were found to be impaired on abstraction and memory tasks (Gur, Gur, & Saykin, 1990). Memory and learning were significantly more impaired than abstraction abilities (WCST) for the patients. The researchers did behavioral imaging simulation studies using the WCST and the California Verbal Learning Test (CVLT). Impaired performance on the WCST was rated by experts as frontal lobe dysfunction and impaired performance on the CVLT was rated as left temporal lobe dysfunction. This research supports frontal and temporal lobe dysfunction, as influencing both abstraction and memory abilities.
Schizophrenia inpatients were less effective at encoding than normal subjects as assessed by degree of organization when asked to recall a speech (Harvey, Earle-Boyer, Wielgus, & Levinson, 1986). The level of encoding was associated with degree of recall of the speech, delayed memory, for both the schizophrenia and normal groups. On random stories, the normal group tended to apply additional organization at recall while the schizophrenia group did not. Also, a group of manic patients was given the same measures with results suggesting a significant relationship between thought disorder and delayed memory. This finding differs from the schizophrenia and control groups where level of encoding related to memory functions.

Research indicates that story delayed recall is significantly different for schizophrenia compared to unipolar and normal control groups (Wood & Flowers, 1990). However, this neuropsychological deficit is shared by the bipolar group. In a follow up study which assessed regional cerebral blood flow during the memory task, the left peri-Sylvian construct (located in the temporal lobe) showed reduced activation specific for schizophrenia as compared to the bipolar, unipolar, and normal control groups. This reduced blood flow would involve Broca's and Wernicke's areas of verbal processing. Thus, this left Sylvian component suggests a context-free memory deficit involved in language processing for schizophrenia patients.

Other research adds to our knowledge of cognitive deficits in verbal learning for schizophrenia subjects. In one study, 50 chronic outpatients were compared with normal controls on the California Verbal Learning Test (Cullum, Kuck, Delis, Heaton, Zisook, & Grant,
1990). The patients were more disorganized and less efficient when they recalled lists of words. The schizophrenia patients made substantially more intrusions during recall. However, both the schizophrenia and control groups had similar rates of forgetting and number of perseverative errors. Both groups made use of simple serial clustering strategies. Cognitive dysfunction appears to impair new verbal learning in schizophrenia patients.

While the locus for verbal memory deficit is usually associated with medial temporal functioning, some research shows involvement with the frontal cortex. Wood and Flowers (1990) found narrative story recall deficit to be related to hypofrontality in schizophrenia, bipolar, unipolar, and normal subjects in a regional cerebral blood flow study. Verbal memory problems showed evidence for laterality with left hypofrontality on the first trial for subjects with greater memory deficits, and right hypofrontality on the last trial for subjects with greater memory deficits. However, this hypofrontality is not specific to schizophrenia and anxiety confounds these findings. These findings provide further evidence for a systemic approach to schizophrenia where multiple areas are involved in cognitive processing rather than a specific region.

Both acute and chronic patients demonstrate substantial neuropsychological impairment. One study compared 32 schizophreniform patients (first episode), 26 chronic schizophrenia patients, and 25 normal control subjects (Hoff, Riordan, O'Donnell, Morris, & Delisi, 1992). Both the acute and chronic patients performed significantly worse on measures of executive function,
concentration/speed, verbal and spatial memory, and global functions. Only the chronic patients performed worse on language functions. Sensory/perceptual functions for the two patient groups were similar to the normal group. With regards to lateralization, the acute and chronic groups were more impaired on both left and right hemisphere tasks than the control group. The left hemisphere was more impaired, compared to the right hemisphere. Thus, both chronic and acute patients have significant cognitive dysfunction with differences only on the language function.

Studies have attempted to delineate differences between positive and negative symptoms and neuropsychological functioning (Strauss, 1993). In a longitudinal study, 38 acute patients were assessed during an acute phase and then retested in six months (Addington, Addington, & Maticka-Tyndale, 1991). On both occasions, negative symptoms were associated with poor performance on verbal reasoning and verbal fluency measures, suggestive of frontal lobe dysfunction. The presence of delusions, positive symptoms, was related to better verbal reasoning on the initial test but was not found 6 months later. At the later assessment, positive symptoms had decreased and cognitive functioning had improved. However, little change was noted in negative symptoms, corresponding with no significant performance change.

In contrast, some studies found that negative symptoms do not correlate with measures of frontal lobe functioning such as the WCST (Green, Satz, Ganzell, & Vaclav, 1992). However, these findings might
have been influenced by the homogeneity of this research group, including more chronic illness and more deficit symptoms.

As with structural abnormalities and brain region deficits, findings are also mixed as to the neurobehavioral consequences of schizophrenia. However, a number of studies point to some disruption of the frontal and temporal lobes, as well as functionally contiguous regions. These connected systems suggest various types of cognitive dysfunctions, especially with certain types of attention, ability to form and shift cognitive sets, new verbal learning and memory, and language functions.

Cognitive Functioning and Rehabilitation

Cognitive functioning, as measured by neuropsychological tests, appears to significantly relate to level of vocational and social functioning (Goldberg et al., 1993). One study in this area was designed to identify neuropsychological predictors of skills training ability in 16 chronic psychiatric patients, including ten schizophrenia, three schizoaffective, two bipolar, and one psychotic NOS disorders (Kern, Green, & Satz, 1992). The cognitive functions of increased verbal learning, sustained visual vigilance, and decreased distractability (increased selective attention) were associated with more appropriate classroom behavior and skill acquisition in symptom management and medication management programs. Executive function, as measured by the Wisconsin Card Sorting Test - perseverative errors, and visual figural memory, as measured by the Rey-Osterreith Complex Figure Test, were not significantly related to skills training as measured in this study. These researchers conclude
that specific methods of skills training may necessitate certain
cognitive processes such as verbal learning, sustained visual
attention, and selective attention.

Cognitive functions such as perception and attention deficits
appear to influence the social judgment in persons with
schizophrenia. In one study, 34 patients viewed video scenes and
then responded to questions about the feelings of the actors (Cramer,
Bowen, O'Neill, 1992). Regardless of the scene, the patient group made
a higher number of verbal responses but utilized fewer of the
adjectives regarding affective state than the normal control group.
The results of a content analysis showed patients made more bizarre
responses, more comments on overall situation, and more comments
on the thoughts, future intentions, and physical appearance of the
actor when compared to controls. However, the patients failed to
comment on the affect of the actors. The researchers suggest that the
difference in schizophrenic patients compared to controls in judging
social situations involves perceptual/attentional dysfunction. The
patients have difficulty in forming new perceptions or modifying
previous perceptions. Schizophrenia patients performance improved,
as noted by other studies, once the general organizing principle was
given to them. Thus, perceptual functioning influences social
judgment.

Negative symptoms appear to relate to social functioning. In a
study of 60 schizophrenia patients with recent onset, social
functioning decreased when negative symptoms were more prevalent
(Van der Does, Dingemans, Linszen, Nugter, & Scholte, 1993). In
contrast to other research, negative and positive symptoms did not relate to cognitive functioning in a linear fashion. However, in a curvilinear analysis, a high and low level of negative symptoms had more cognitive impairment than a moderate level of negative symptoms. Level of cognitive disorganization, measured apart from positive and negative symptoms, was related to the Modified Wisconsin Card Sorting Test. While some type of relationship is assumed, this study did not make a direct comparison of cognitive functions with social functioning. This type of analysis would be helpful in defining the relationship.

In a review of issues affecting psychosocial treatment, the knowledge of cognitive dysfunctions in schizophrenia patients has had minimal impact on rehabilitation (Bellack & Mueser, 1993). Findings are mixed in how amenable cognitive deficits are to rehabilitation in patients with schizophrenia (Vollema, Geurtsen & vanVoorst, 1995). These researchers suggest a need for knowing how cognitive dysfunction affects treatment, i.e. learning and memory issues. Bellack and Mueser cite an earlier study (Mueser, Bellack, Douglas, and Morrison, 1991) which found memory deficits significantly related to difficulties in social skills training. Symptoms, as evaluated prior to training, were not associated with skill achievement. Research is needed to further delineate the impact of cognitive functioning on social, vocational, and independent living skills.

Wilson (1993) addressed the need to devise neuropsychological tests that are relevant to everyday behaviors. This researcher helped
to devise the Rivermead Behavioural Memory Test; questions were based on real life performance. In a follow up study of 54 patients seen for memory dysfunction, the RBMT significantly discriminated between independent subjects, i.e. employed, living alone, and dependent subjects. The Wechsler Memory Scale-Revised did not significantly distinguish independent from dependent living skills. More research is needed to assess the relationship between neuropsychological tests and functional living skills.

In conjunction with rehabilitation, both patients with schizophrenia and their family members are interested in learning more about the mental disorder, strategies for solving problems, and utilization of the mental health system (Mueser, Bellack, Wade, Sayers, & Rosental, 1992). Several researchers investigated strategies that patients used to cope with specific symptoms i.e. auditory hallucinations (Kingdon & Turkington, 1994). Specific cognitive coping strategies included suppression of disturbing thoughts/hallucinations, redirection of thoughts, and problem solving. Knowledge of cognitive functioning which characterizes schizophrenia may benefit patients and their families, as well as mental health professionals in developing effective treatment strategies.

Some evidence supports the positive benefits of rehabilitation for chronic patients with schizophrenia. One longitudinal study included chronic, disabled patients who had received a comprehensive rehabilitation program and were released to the community 20 to 25 years prior to this study (Harding, Brooks, Ashikaga, Strauss, & Breier, 1987b). At follow-up, 68% of the subjects
did not exhibit any positive or negative symptoms of schizophrenia. Levels of functioning were variable with 81% able to meet basic needs, 73% able to lead moderate to full life, and 40% employed. Psychotropic medications were still prescribed for 84% of them, although 34% of these subjects were rated as noncompliers. Thus, about 50% of the patients were not using medication. A significant difference between the schizophrenia subjects and those from other diagnostic categories (affective disorders, organic disorders, alcoholism), using DSM III criteria, was fewer close friendships for subjects with schizophrenia. These same patients showed improvement from an earlier 10 year follow-up study (Harding, Brooks, Ashikaga, Strauss, & Breier, 1987a). While some rehabilitation programs appear to contribute to long term positive outcome, further understanding of the relationship between cognitive functioning, behavioral symptoms, and rehabilitation may aid in increased efficacy of rehabilitation programs and the long term adjustment of patients.

Summary and Statement of Hypothesis

Cognitive theories and models provide a base for understanding the interrelationships between anatomical abnormalities, cognitive dysfunction, and the behavioral symptoms of schizophrenia. Prior research has shown that persons with schizophrenia have impaired cognitive functions that continue years after the acute phase. These deficits affect functional abilities and overall quality of life. While some evidence points to impairment with executive, language, and
memory functions, conclusions have been mixed as to the exact nature of these impairments.

In order to clarify and expand the reviewed research, this study compared cognitive functioning of patients with schizophrenia, to a psychiatric patient group with bipolar disorder and a normal control group. The following hypothesis was investigated:

Subjects with schizophrenia would differ significantly on measures of cognitive functioning when compared to a psychiatric group and a normal control group. More specifically, persons with schizophrenia would perform significantly worse on measures of frontal lobe functioning in comparison to a bipolar and normal control group.
Subjects
Subjects consisted of 21 patients with a diagnosis of schizophrenia, 20 patients with a diagnosis of bipolar disorder, manic phase, according to the DSM III-R criteria (American Psychiatric Association, 1987), and a group of 20 normal subjects (Table 1, Appendix A). Subjects were excluded if their current working diagnosis included alcohol or drug dependence and/or significant neurological injury or illness, i.e. head injury with coma, seizure disorder. Subjects were hospitalized patients of Terrell State Hospital between the ages of 19 and 49 for the schizophrenia group (mean = 38.05±8.22) and 19 and 51 for the bipolar group (mean = 39.00±9.97). The control group of 20 normal subjects had a history negative for substance dependence, neurological disorders, and personal and family mental illness. The control group were employees at Terrell State Hospital between the ages of 23 and 49 (mean = 32.45±7.06).

Length of current hospitalization in the schizophrenia group was less than one year for 18 subjects, one to two years for two subjects, and more than two years for one subject. The length of hospitalization was less than one year for all 20 bipolar subjects. Twelve of 17 schizophrenia subjects and 12 of 16 bipolar subjects
were in the hospital five or more times. A history of drug abuse was positive for nine of 20 schizophrenia subjects and 13 of 20 bipolar subjects.

Fifteen of 21 schizophrenia subjects were right-handed; one was left-handed, and five were ambidextrous as measured by a handedness questionnaire (Oldfield, 1971). Nineteen bipolar patients were right-handed and one was left-handed. Sixteen right-handed, one left-handed, and three ambidextrous subjects were identified in the normal control group. The schizophrenia group had six Caucasian, 14 black, and one Hispanic subjects. The bipolar group consisted of 16 Caucasian and four black subjects and the normal control group had 13 Caucasian, five black, and three Hispanic subjects. There were 14 males and seven females in the schizophrenia group, 12 males and eight females in the bipolar group, and six males and 14 females in the normal control group.

Results from six subjects were not included in the analysis due to language difficulties for two subjects where English was a second language, a medical condition which might affect neuropsychological functioning, significant difficulties with on task behavior, and an interruption during a memory test.

Procedures

All subjects were informed of the nature of the study and a signed written consent was obtained prior to participation (Appendix B). Subjects completed a series of neuropsychological assessment instruments and a global measure of intellectual functioning. Each subject was assessed individually with total testing time ranging from
90 to 150 minutes. Midway through the assessment procedures all subjects were given a 5-10 minute break. Testing was completed in more than one session for some subjects. In exchange for each subject's voluntary participation, a monetary reinforcer of 5 dollars was given when all tasks were completed. All measures were administered by the principal investigator, a counseling psychology Ph.D. doctoral candidate, under the supervision of a licensed psychologist.

Demographic data on the patients were collected from the file, including sex, age, medications, length of hospitalization, marital status, diagnosis, and other mediating factors. A nurse and a social worker or mental health worker most in contact with the patient were asked to rate the patient on a scale measuring functional behaviors. Also, the psychologist on the patient's treatment team rated the patient on the scales for negative and positive symptoms, the Brief Psychiatric Rating Scale, and on DSM III-R criteria. A specific interview was not done for each of these rating scales. These forms were completed on 15 of the schizophrenic subjects and seven of the bipolar patients.

Instruments

Primarily Frontal Functions

Controlled Oral Word Association (Word Fluency)

This procedure measures the fluency of verbal association of individual words (Spreen & Benton, 1969). The subject is given a letter from the alphabet, (F, A, and S), and then expected to spontaneously produce words beginning with this letter. Normative
data were obtained from a study by Yendell, Fromm, Reddon, and Stefanyk (1986). Retest reliability ranges from .6 to .88 (Spreen & Benton, 1991). This test appears sensitive to frontal lobe impairment, especially to lesions of the left frontal lobe. One PET-scan study suggests bilateral involvement of both the frontal and temporal lobes (Parks, Loewenstein, Dodrill, Barker, Yoshii, Chang, Emran, Apicella, Sheramata, & Duara, 1988).

**Stroop Color and Word Test**

Originally devised by Stroop (1935), this test has been modified and standardized (Golden, 1978). The Stroop appears to measure mental flexibility and selective attention, the ability to screen out extraneous stimuli, usually suggestive of frontal lobe functioning. The test consists of three pages with 100 items and a 45-second time limit for each page. On the first page the examinee is asked to read the words "RED," "GREEN," and "BLUE" written in black ink and arranged randomly. The examinee names the color of items written as "XXXX" and printed in either blue, green, or red ink on the second page. The third page consists of the words on page one printed in the colors of page two, with the name not matching the color of ink. The subject is asked to name the color of ink while ignoring the color name. Four scores are derived from the subject's performance, including Word Score (page 1), Color Score (page 2), Color-Word Score (page 3) and an Interference Score. Golden summarizes reliability studies on different versions of the Stroop with test-retest reliabilities ranging from .69 to .89 for the three raw scores.
Trail Making Test for Adults, Parts A and B

Originally, the Trail Making Test was part of the Army Individual Test Battery (1944). The test was later added to the Halstead-Reitan Neuropsychological Test Battery (Reitan & Wolfson, 1993). Part A consists of 25 circled numbers which requires the examinee to connect them with a line drawn in numerical order. Part B has 25 circles with numbers (1-13) and letters (A-L). The subject must connect the circles in order, alternating between numbers and letters (1--A--2--B). Each part is scored according to amount of time needed for completion. Lezak (1983) reported retest reliability for Part A as .98 and Part B as .67. Retest reliability appears to be substantially reduced for subjects with schizophrenia, .36 for Part A and .63 for Part B. However, retest reliability was found to be from .64-.94 for Part A and from .66-.86 for Part B for other neurologically impaired groups (Goldstein and Watson, 1989). While Part A involves sensory motor functions, Part B appears to also involve cognitive flexibility suggestive of frontal lobe functioning. Normative data which takes into account gender, age, and education were used for T scores on Part A and Part B (Heaton, Grant, & Matthews, 1991).

Wisconsin Card Sorting Test (WCST)

The WCST, as standardized by Heaton (1981), is used to assess abstraction and mental flexibility which appear to be sensitive to brain dysfunction in the frontal lobes. Stimulus and response cards have figures with geometrical shapes, colors, and numbers. Four stimulus cards are placed in front of the subject, including one red triangle, two green stars, three yellow crosses, and four blue circles.
The subject is asked to match each of the 168 response cards to one of the stimulus cards. The subject is told whether the response is right or wrong but no other feedback is given. After ten consecutive correct sorts, the sorting principle is changed. The examiner gives no feedback on shifts in the sorting principle nor input on types of sorting principles. Several scores are possible from the test, including total number of errors, total number of correct responses, number of categories completed, perseverative responses, perseverative errors, nonperseverative errors, percent perseverative errors, trials to complete the first category, failure to maintain set. Normative data are for normal and brain impaired subjects, frontal and nonfrontal. No reliability studies are given.

**Primarily Temporal Lobe Functions:**

**California Verbal Learning Test (CVLT)**

The CVLT (Delis, Kramer, Kaplan, & Ober, 1987) is a multifactorial assessment of verbal learning and memory. This test provides normative data on how a task is solved, including strategies, processes, errors, and on short and delayed retention. Each subject is asked to recall a list of 16 words over five trials, as given orally by the examiner; these 16 words can be grouped into four semantic categories. After the five trials, an interference list of words is presented and recalled. The subject is then asked to recall the initial list, using both free and category-cued. Following a 20-minute delay, the examiner assesses free recall, cued recall, and recognition of the
initial list. Internal reliability studies for the CVLT conducted by the authors of the instrument indicate internal consistency coefficients from .69 to .92.

**Wechsler Memory Scale-Revised (WMS-R)**

The WMS-R is a revision of the Wechsler Memory Scale which was written in 1945 (Wechsler, 1987). The Logical Memory Subtests I (immediate) and II (delayed) will be used to assess verbal learning and retention of a logical story. Two stories with equivalent levels of difficulty are read orally to the subject. At the end of each story, the subject is asked to recall it verbatim. After 30 minutes have elapsed, the subject is again asked to recall the stories. This test gives a score for both immediate and delayed verbal memory. Test-retest reliability for Logical Memory I was .64 to .67 for ages 20 to 64. Logical Memory II had reliability coefficients of .70 to .72 for these same age groups.

**Rey-Osterrieth Complex Figure Test**

This test was developed by Rey (1941) and Osterrieth (1944) to measure visual spatial constructional abilities and delayed memory. Administration consists of the subject copying the figure and then recalling this figure after a 30 minute delay. Difficulty with the delayed memory portion suggests right temporal lobe dysfunction, when the figure was originally copied correctly. Normative data may be found in summaries provided by Spreen and Strauss (1991). Interrater reliability according to strict scoring criteria was found to
be above .95. On test-retest, normal subjects demonstrate a ten percent improvement in delayed recall, suggesting practice effects.

**Intellectual Assessment**

**Kaufman Brief Intelligence Test (K-BIT)**

The K-BIT is a screening measure of intellectual abilities, including Verbal, Matrices (nonverbal), and Composite scores (Kaufman & Kaufman, 1990). The verbal performance subtests include vocabulary and naming. The nonverbal performance test involves analogies requiring visuospatial reasoning. This test was normed on subjects ages 4-90. One validity study of neurologically impaired patients suggests that K-BIT scores tend to be 5 points higher compared to WAIS-R scores (Naugle, Chelune, & Tucker, 1993).

**Diagnostic Assessment**

**Functional Assessment**

An unpublished assessment of functional skills was developed by David Hogue, Ph.D., and professional staff from the Psychosocial Rehabilitation Unit, Terrell State Hospital. A portion of this assessment was used in this study. A nurse and social worker or mental health worker rated each subject on social, vocational, independent functioning, and leisure skills.

**Scale for the Assessment of Negative Symptoms-SANS**

This scale evaluates five negative symptoms common to schizophrenia, including alogia, affective blunting, anhedonia, avolition, and attention dysfunction (Andreasen, 1983). Each of the individual subscales includes a global rating for that symptom. The scale for alogia includes blocking, increased latency of response and
poverty of speech and content of speech. The affective flattening scale includes unchanging facial expression, decreased spontaneous movements, paucity of expressive gestures, poor eye contact, affective nonresponsivity, and lack of vocal inflections. The avolition scale measures impersistence at work, physical anergia, and grooming and hygiene. Anhedonia is a rating of the patient's recreational interests, friendships, sexual activity and ability to feel intimacy. Social inattentiveness and inattentiveness during mental status testing, as well as the global rating, make up the rating for the attention symptom.

A clinician/rater evaluates degree of severity on each of the symptoms from none to severe, 0 to 5 point scale. Test-retest reliability ranged from .38 on poverty of speech to .76 on affective blunting (Andreasen, Flaum, Arndt, Alliger, Swayze, 1991). Interrater reliability ranged from .66 to .81 on this study. In validity studies, the researchers report good internal consistency both within individual scales and between the individual scales of the SANS Scale for the Assessment of Positive Symptoms-SAPS

The SAPS provides a measure of positive symptoms; the scales include hallucinations, delusions, positive formal thought disorder, bizarre behavior, and inappropriate affect (Andreasen, 1984). Each symptom rating includes a global measure as well as specific components. The hallucinations scale includes auditory, visual, somatic, and olfactory hallucinations. The delusions scale includes ratings of the following types of delusions: persecutory, jealousy, guilt, grandiose, religious, somatic, reference, being controlled, mind
reading, and in addition thought broadcasting, thought insertion and thought withdrawal. Bizarre behavior includes appearance, social, aggressive/agitated, and repetitive or stereotyped behavior. Positive formal thought disorder is a measure of derailment, tangentiality, incoherence, illogicality, circumstantiality, clanging, pressured speech, and distractible speech. Inappropriate affect includes only the global measure for that symptom. A clinician/rater evaluates and rates each of the symptoms, according to level of severity (0-5). Both the SANS and the SAPS were designed to be sensitive to change so as to increase the scales' usefulness in clinical diagnosis and treatment planning and evaluation.

Test-retest reliability ranged from .50 on bizarre behavior to .71 on delusions, with interrater reliability from .62 to .93 (Andreasen, Flaum, Arndt, Alliger, Swayze, 1991). Validity studies of the SAPS report relatively poor internal consistency. However, these results are consistent with clinical observation, where a patient may exhibit one positive symptom but not another (i.e. hallucination but no formal thought disorder). In factor analytic studies of the SANS and the SAPS, three factors emerge. The first factor includes all five negative symptoms; the second factor weights on delusions and hallucinations, two of the positive symptoms; and a third factor weights on positive formal thought disorder and bizarre behavior. Findings from these factor analytic studies suggest that the positive symptoms, as assessed by the SAPS, are in two somewhat independent classes with one representing psychoticism and the other disorganization.
Brief Psychiatric Rating Scale-BPRS

The BPRS was originally developed and published in 1962 by Overall and Gorham to assess treatment response in patients (Thompson, 1989, van Riezen & Segal, 1988). This measure has 18 items which are rated for severity on a zero to seven point scale. The BPRS total score has frequently been used for assessment of schizophrenia although this score does not clearly differentiate between psychotic, neurotic, or affective groups. In the current study, patients were rated by the psychologist from their treatment team on this scale to assist in clarification of psychiatric diagnosis.
CHAPTER III

RESULTS

The primary objective of the study was to determine if there were significant differences among the schizophrenia, bipolar, and normal control groups on measures of neuropsychological functioning (WCST Categories, WCST Perseverative Errors, Trails B Time T Score, Controlled Oral Word Association Total, Stroop Interference T Score, CVLT delayed free recall, Rey Figure delayed memory, WMS-R logical stories delayed memory). Means and standard deviations for the dependent variables as listed above are presented in Table 2 (Appendix A). Data were analyzed by a one way multivariate analysis of variance which found a significant overall effect (Wilks’ Lambda = 0.22, \( F = 7.24, \text{df} = 16,102, p < 0.001 \)). Univariate F-tests (\( \text{df} = 2,58 \)) on the individual variables showed significant differences between groups (\( p < 0.01 \)) on each of the neuropsychological measures.

Neuman-Keuls follow-up tests indicated significant differences between each of the schizophrenia, bipolar, and normal groups on the COWA Total, Trails B Time T Score, WCST number of categories, WCST perseverative errors, and CVLT long-delay free recall. The normal group was found to be significantly different from the two patient groups on the Stroop Interference T Score, WMS-R delayed story
percentile, and the Rey Figure delayed memory. The schizophrenia group and the bipolar group were not significantly different on the Stroop Interference T Score, WMS-R delayed story percentile, and the Rey Figure delayed memory.

In addition, the impact of demographic data and the relationship among neuropsychological tests were examined. Correlational analyses were done among the neuropsychological variables and between each neuropsychological variable and the demographic facts. On the basis of this correlational analysis, a multivariate analysis of covariance (MANCOVA) was done followed by univariate analyses of covariance (ANCOVA) with education and intellectual level as the covariates. The MANCOVA indicates significant differences among groups (Wilks' Lambda = .38, F = 3.98, df = 16.98, p < 0.001). The ANCOVAs found significant effects for group differences on the WCST categories, WCST perseverative errors, COWA total, Trails B Time T score, CVLT delayed free recall, Rey delayed memory, and WMS-R logical stories delayed memory. With education and intellectual level as covariates, the Stroop Interference T score did not significantly discriminate among groups.

The K-Bit was used as a brief cognitive measure of intellectual functioning. The schizophrenia group had a composite score mean of 73.48 (+11.97), a vocabulary standard score mean of 77.00 (+11.77), and a matrices standard score mean of 75.24 (+13.92). The bipolar group had a composite score mean of 91.75 (+11.99), a vocabulary standard score mean of 94.65 (+10.05), and a matrices standard score mean of 90.40 (+13.20). The normal subjects had a composite score
mean of 99.65 (± 10.19), a vocabulary standard score mean of 102.00 (± 9.43), and a matrices standard score mean of 97.45 (± 10.86). See Table 3.

Neuropsychological variables were correlated with the ratings given by the psychologists on the SANS and the SAPS for 15 of the schizophrenia patients and seven of the bipolar patients. The COWA Total score, Trails B Time T score, and WMS-R delayed logical memory score were significantly negatively correlated while the WCST perseverative errors was significantly positively correlated with the SANS total score (p < 0.05). Both the delayed memory score of the CVLT (p < 0.01) and the Trails B Time T (p < 0.05) were significantly correlated with the SAPS.

The Brief Psychiatric Rating Scale significantly correlates (r = 0.7137, p < 0.01) with the Scale for the Assessment of Positive Symptoms on a combined group of 15 schizophrenia and 7 bipolar subjects. A smaller, but still significant, relationship was found between the BPRS and SANS (r = 0.5106, p < 0.05).

A total percent score of behaviors observed was obtained on the functional analysis as rated by a nurse and/or a social worker or mental health worker on the subject's treatment team. The mean from these two functional behavior scores was then correlated with the neuropsychological variables (WCST Categories, WCST Perseverative Errors, Trails B Time T Score, Controlled Oral Word Association Total, Stroop Interference T Score, CVLT delayed free recall, Rey delayed memory, WMS-R logical stories delayed memory). Only the Trails B Time T Score was shown to correlate significantly
with the patient's functional level percent score ($p < 0.05$). Thus, poorer performance time on a neuropsychological task of mental flexibility suggests a poorer rating on functional behaviors. Another correlational analysis was completed, comparing sixteen of the total percent functional behavior ratings by the nurse and by the social worker/mental health worker. The nurses scores and the social workers/mental health workers scores were significantly correlated ($r = 0.76$, $p < 0.01$).

Follow-up analyses were done on each of the following tests to determine more specific differences among the schizophrenia, bipolar, and normal groups: Wisconsin Card Sorting Test (WCST), Trail Making Test (Trails), Controlled Oral Word Association (COWA), Stroop Color and Word Test, California Verbal Learning Test (CVLT), Wechsler Memory Scale-Revised (WMS-R), Rey-Osterrieth Complex Figure (Rey), and Kaufman Brief Intelligence Test (K-BIT). On the WCST, the dependent variables were number of categories completed, perseverative responses, perseverative errors, nonperseverative errors, percent perseverative errors, trials to first category, percent conceptual responses, and failure to maintain set. Table 4, Appendix A, includes means and standard deviations for these variables. A significant effect was found in a one way multivariate analysis of variance ($\text{Wilks' Lambda} = .22$, $F = 4.04$, $df = 16,102$, $p < 0.001$). Univariate F-tests ($df = 2,58$) on each of the individual WCST variables found significant differences on all variables except for trials to first category and failure to maintain set. A MANCOVA, with education and intellectual level as covariants, found significant
differences among groups (Wilks' Lambda = 0.52, $F = 2.03$, $df = 18.96$, $p < 0.05$). ANCOVAs for each WCST variable showed significant differences among the groups for categories, perseverative responses, perseverative errors, nonperseverative errors, and percent perseverative errors.

Neuman-Keuls analyses of the WCST variables showed significant differences between each group on number of categories completed, perseverative responses, perseverative errors, and percent conceptual responses. The normal group was significantly different from the schizophrenia group and the bipolar group on nonperseverative errors. Only the schizophrenia group was significantly different from the normal group on percent perseverative errors.

Variables on the Trails included Trails A time, Trails A time T, Trails B time, and Trails B time T. Mean performances on these variables are in Table 5, Appendix A. Results of a MANOVA showed significant differences among the schizophrenia, bipolar, and normal groups (Wilks' Lambda = 0.40, $F = 7.99$, $df = 8.110$, $p < 0.001$). Follow-up univariate F-tests ($df = 2.58$, $p < 0.001$) showed a significant difference among the groups for each variable. When education and intellectual level were statistically controlled (MANCOVA), a significant difference was found among the three groups (Wilks' Lambda = 0.71, $F = 2.41$, $df = 8.106$, $p < 0.05$). In subsequent ANCOVAs, significant differences were found among the groups for each variable with the exception of Trails A time. Results of the Neuman-Keuls indicated significant differences among the
A MANOVA was conducted to determine whether there were any significant differences among groups on specific scores from the Controlled Oral Word Association, including the "F" raw score, "A" raw score, "S" raw score, and perseverative score. Table 6 (Appendix A) has mean performance scores. Results showed significant differences among groups (Wilks' Lambda = 0.39, $F = 8.25$, $df = 8,110$, $p < 0.001$). Univariate F-tests found significant differences among the groups for all the variables ($df = 2,58$, $p < 0.01$). With intellectual level and education as covariates, a MANCOVA also found significant differences among the three groups (Wilks' Lambda = 0.65, $F = 3.20$, $df = 8,106$, $p < 0.01$). Follow-up ANCOVAs showed significant differences for the "F" and "S" raw scores ($df = 2,56$, $p < 0.01$) but not for the "A" raw score or perseveration score.

Neuman-Keuls analyses indicated significant differences among each of the schizophrenia, bipolar, and normal groups on the "F" raw score and the "S" raw score. On the perseverative score, both patient groups differed from the normal group but this variable did not significantly differentiate between the patient groups. The schizophrenia group was significantly different from both the bipolar and the normal groups on the "A" raw score.

On the Stroop, the eight dependent variables were the Word raw score, Word T score, Color raw score, Color T score, Color-Word raw score, Color-Word T score, Interference raw score, and the Interference T score. Mean performances for the dependent
variables are in Table 7 (Appendix A). The MANOVA found a significant overall difference (Wilks' Lambda = 0.28, $F = 6.45$, $df = 16,102$, $p < 0.001$). Subsequent ANOVAs found significant differences among the schizophrenia, bipolar, and normal groups for each variable ($df = 2,58$, $p < 0.01$). The MANCOVA, controlling for education and intellectual level, also found a significant overall effect (Wilks' Lambda = 0.46, $F = 2.90$, $df = 16,98$, $p < 0.01$). ANCOVAs for each dependent variable showed significant differences among the groups for all variables ($df = 2,56$, $p < 0.01$) except for the Interference raw score and the Interference raw T score. Neuman-Keuls analyses found significant differences among each of the groups on all variables except the Interference raw score and Interference T score. However, the patient groups were significantly different from the normal group on these two variables.

Variables analyzed on the CVLT were trials 1-5 total standard score, List A short-delay free recall, List A short-delay cued recall, List A long-delay free recall, List A long-delay cued recall, perseverations - total score, recognition hits, short-delay free recall compared to List A trial 5 - percent change, long-delay free recall compared to short-delay free recall - percent change, recognition hits compared to long-delay free recall - percent change. Means and standard deviations for the variables listed are presented in Table 8 (Appendix A). A MANOVA with the above dependent variables found significant differences among the schizophrenia, bipolar, and normal groups (Wilks' Lambda = 0.29, $F = 4.24$, $df = 20,96$, $p < 0.001$). Follow-up ANOVAs for each variable resulted in significant differences ($df = $
2.58, p < 0.05) for all variables except perseverations - total score and long-delay free recall compared to short-delay free recall - percent change. A MANCOVA, with education and intellectual level as covariates, was also significant (Wilks' Lambda = 0.44, F = 2.38, df = 20.94, p < 0.01). ANCOVAs showed significant differences among the groups on the following variable: trials 1-5 total standard score, List A short-delay cued recall, List A long-delay free recall, List A long-delay cued recall, and recognition hits (df = 2.56, p < 0.05).

Neuman-Keuls analyses of the CVLT variables indicated significant differences between each group on trials 1-5 total standard score, List A short-delay free recall, List A short-delay cued recall, List A long-delay free recall, List A long-delay cued recall. See Table 8, Appendix A. The schizophrenia group differed from the normal and bipolar groups on short-delay free recall compared to List A trial 5 - percent change, and recognition hits compared to long-delay free recall - percent change. On recognition hits, the schizophrenia group was not significantly different from the bipolar and normal groups. However, the bipolar group was significantly different from the normal group.

Five variables from the Wechsler Memory Scale-Revised logical stories were the dependent variables, including Immediate Memory percentile, Immediate Memory raw score, Delayed Memory percentile, Delayed Memory raw score, and a Percent Retention score. Means and standard deviations are listed in Table 9 (Appendix A). A MANOVA testing differences between the schizophrenia, bipolar, and normal groups was statistically significant. (Wilks' Lambda = 0.21, F =
12.27, \( df = 10,108, p < 0.001 \). Univariate ANOVAs were all significant (\( df = 2.58, p < 0.01 \)). A MANCOVA, with education and intellectual level as covariates, revealed significant differences among the groups on all of the WMS-R variables tested. In further analyses, univariate ANCOVAs were all significant on the WMS-R variables (\( df = 2.56, p < 0.05 \)).

Follow-up Neuman-Keuls showed significant differences among the schizophrenia, bipolar, and normal groups on the WMS-R logical stories immediate memory raw score, and the delayed memory raw score. The normal group was significantly different from the bipolar and the schizophrenia groups on the Immediate memory percentile, delayed memory percentile, and a percent retention score. However, the patient groups were not significantly different on these three variables.

In examining the differences between the schizophrenia, bipolar, and normal group on visual-spatial memory, two tasks from the Rey were used as dependent variables, including immediate copy raw score and delayed memory raw score. See Table 10 (Appendix A) for means and standard deviations. A MANOVA was significant (Wilks' Lambda = 0.52, \( F = 11.13, df = 4,114, p < 0.001 \)). Subsequent univariate F tests were also significant on the immediate and the delayed tasks (\( df = 2.58, p < 0.001 \)). When controlling for intellectual level and education, results of a MANCOVA continued to show significant differences among the groups (Wilks' Lambda = 0.72, \( F = 4.98, df = 4,110, p =0.001 \)). The ANCOVAs indicated that the delayed copy score was the only variable showing significant differences
among the groups (df = 256, p < 0.001) when intellectual level and education were statistically controlled. Neuman-Keuls follow-up analyses indicated significant differences between the normal group and the patient groups on both the copy and the delayed tasks but no significant differences between the patient groups.
CHAPTER IV

DISCUSSION

With some variability in findings, previous investigations tend to substantiate frontal lobe involvement in patients with schizophrenia. In accord with these findings, patients with schizophrenia performed significantly worse than bipolar and normal subjects on neuropsychological measures sensitive to frontal lobe functions (WCST Categories, WCST Perseverative Errors, Trails B Time T Score, Controlled Oral Word Association Total, Stroop Interference T). The current results suggest significant differences among the three groups on the frontal tasks even when controlled for education and intellectual level with the exception of one interference task. These findings demonstrate that many of the differences among the three groups cannot be accounted for by educational and/or intellectual differences. Schizophrenia subjects tend to have less cognitive flexibility, more difficulty correcting for errors, problems integrating feedback, probable loss of task set, and limited verbal response repertoire. These functions are consistent with prior research on the frontal lobes, especially the dorsolateral prefrontal area (Malloy & Richardson, 1994). However, the small sample size of the current study limits the generalizability of the results. Multiple
research sites in future studies should be considered to enlarge sample size.

The findings suggest a significant difference between each of the three groups on the following frontal functions: verbal fluency, ability to shift cognitive set, perseverative errors, and mental flexibility on an alternating numbers and letters task. Thus, the schizophrenia group had more difficulty on these tasks than either the bipolar or normal group. The bipolar group was significantly different from the normal group on these tasks. While the schizophrenia and bipolar groups were significantly different from the normal group on the Stroop Interference T Score, these groups were not significantly different from each other. Thus, the patient groups had more difficulty with the ability to screen out extraneous stimuli as compared to the normal group.

Delayed memory tasks were used to assess temporal lobe functions. Schizophrenia subjects had significant difficulty, as compared to the normal group, on both verbal and nonverbal memory, suggesting both left and right temporal cortex involvement. Specifically, performance was impaired on a verbal memory task for a list of words (CVLT delayed free recall) for patients with schizophrenia compared to patients with bipolar disorder and normal control subjects. Schizophrenia patients were also significantly impaired on verbal memory of logical stories and figural memory as compared to normal subjects. While significant differences were found between the schizophrenia and normal groups, there were not significant differences between the schizophrenia and bipolar groups.
on Rey delayed visual memory and WMS-R delayed logical stories memory. Findings are consistent with a study by Wood and Flowers (1990), which showed no significant differences between subjects with schizophrenia and bipolar disorder on a story memory test.

Current findings on memory impairment are in contrast to a study by Cullum, etc. (1990). Schizophrenia subjects in the current study were significantly impaired on the delayed free recall portion of the California Verbal Learning Test whereas the earlier study showed no significant differences. However, other research, involving behavioral imaging simulations studies, showed impaired performance by schizophrenia patients on the CVLT which also related to left temporal lobe dysfunction (Gur, Gur, & Saykin, 1990). Further research is needed to discern the relationship between verbal learning and memory, and impairment in schizophrenia.

On a brief intellectual measure, the mean composite score for the schizophrenia group was significantly below average. The mean composite scores for the bipolar and normal groups was in the average range. These findings are consistent with a recent study which found similar patterns in intellectual functioning between schizophrenia and bipolar subjects, as well as schizophrenia and normal subjects (Harrell, Gard, & Poreh, 1995). It is difficult to partial out intellectual functioning from the disease process in schizophrenia, as intellectual deficiencies may be a consequence of the disease. Also, given age at onset, educational and learning experiences may become limited.
Results showed an increase in the rating of negative symptoms significantly related to a decrease in verbal fluency, a longer time needed to complete a mental flexibility task (lower T score), and less remembered on a delayed logical verbal memory task for a group of the schizophrenia and bipolar patients. An increase in the total score of negative symptoms significantly correlated with an increase in perseverative errors on the WCST. Results indicate that an increase in the rating of positive symptoms suggests a decrease in verbal delayed memory for a list of words and an increase in the time needed to complete a nonverbal mental flexibility task.

Previous research suggests similarities as well as differences with the current findings when correlating positive and negative symptoms with neuropsychological variables (Morrison-Stewart, etc. 1992). In both the current study and the Morrison-Stewart study, the logical verbal memory significantly correlated with both the SANS and the SAPS. However, in the Morrison-Stewart study the WCST perseverative errors significantly correlated with the SAPS but not the SANS while the current findings suggest significant correlations with the SANS but not the SAPS. Verbal fluency did not correlate with either measure in the previous study. The differences between the current study and the Morrison-Stewart findings may be due to the small sample size of both studies or to different sample characteristics. Also, in the current study, nine different psychologists provide the ratings. Previous research, using six to 12 psychiatrists as raters, found significant interrater reliability but with
moderate to low correlations on the SANS (Mueser, Sayers, Schooler, Mance, & Haas, 1994).

While the current research lends some support for distinct pathophysiologies for positive and negative symptoms, the findings are mixed and may also suggest the interrelatedness of brain regions (Villenueve, 1994). Also, the mixed findings may support a multifactor theory better than the positive/negative dichotomy. Future research should utilize a larger sample size and if possible, a smaller number of raters.

Only one of the neuropsychological tasks was significantly correlated with the patients' overall functional level as rated by a nurse and social worker or mental health worker. Patients with lower ratings on functional behaviors took more time to complete a task of mental flexibility. Given that many of the schizophrenia subjects did not complete this task, this group showed severe impairment in their ability to shift cognitive sets on this sequencing task. These cognitive abilities appear to significantly relate to the person's performance/skill level in social and vocational domains, independent functioning and leisure time functioning, as perceived by professional staff.

Similar to our current findings, previous research has shown few relationships between some neuropsychological tasks and functional behaviors (Kern, Green, & Satz, 1992). For example, the Wisconsin Card Sorting Test and the Rey-Osterrieth Complex Figure Test were not significantly related to skills training. Further development of neuropsychological tests, related to everyday
functioning, is needed to clarify the relationship between impaired cognitive functions and the behaviors of schizophrenia patients.

Additional analyses were done on each neuropsychological tests. While these additional analyses increase the likelihood of Type I error, the findings assist in understanding the exact nature of the differences between the schizophrenia, bipolar, and normal subjects. On the WCST, schizophrenia subjects' number of trials needed for initial conceptualization of the first category was not significantly different from either of the other groups. The schizophrenia subjects had significant difficulties though when it became necessary to switch cognitive sets as compared to the bipolar and normal subjects. Schizophrenia subjects' problems in changing cognitive sets may be influenced by their significant perseveration problems. Subjects with schizophrenia had significantly less insight into correct sorting principals than the bipolar subjects who had less insight than normal subjects. Schizophrenia subjects were not significantly different from the other two groups on failure to maintain set. This finding may be a reflection of the schizophrenia group having difficulty even developing a different cognitive set. These findings support previous research which suggests that schizophrenia subjects are able to maintain a cognitive set once developed but have difficulty in generating and shifting cognitive sets (Goldman, etc., 1992).

Results of the Trails A and B subtests showed significant differences between each of the three groups for both tests. Thus, the schizophrenia group took significantly longer to complete a nonverbal attention task as well as a task of mental flexibility. Both tasks
required sequencing. However, when years of education and intellectual level were covariates, no significant differences were found among the three groups on the attention task.

Verbal fluency was significantly less on each of the letters (F, A, S) for schizophrenia subjects as compared to the bipolar or normal subjects. Both patient groups had some difficulty with perseverative responses while the normal group had no perseverative responses.

Schizophrenia, bipolar, and normal subjects were each significantly different from each other on several subtests of the Stroop, including Word, Color, and Color Word with the schizophrenia group performing significantly lower than the other groups. As previously cited, an interesting finding on the Stroop was that when education and intellectual level were controlled, no significant differences where found among the groups on the Interference score. However, post hoc analyses of the ANOVA found a significant difference between the normal group and the patient groups on the Interference score but this score did not significantly differentiate between the patient groups. These patterns with the Interference score are difficult to interpret. Golden (1978) suggests that there is usually left hemisphere or diffuse cognitive dysfunction when all the scores are low. If the interference score is normal, with the other scores low, then this pattern is more indicative of a diffuse problem.

Verbal learning and memory problems appear pronounced for the schizophrenia patients as compared to the bipolar and normal subjects even when controlling for education and intellectual level. The CVLT normative data also controls for age and sex on the verbal
learning score. Schizophrenia subjects were significantly impaired on both free and cued recall for both short and delayed memory tasks on the CVLT as compared to the bipolar and normal subjects. Problems with both the free and cued recall portions of the test usually suggest problems in encoding (Delis et al., 1995).

The schizophrenia group was not significantly different from the bipolar and normal groups on the verbal recognition task of the CVLT. The large positive difference between the number of recognition hits and the number of words recalled on the long-delay free recall task for the schizophrenia group would usually suggest that recognition is better than free recall, and that retrieval may be more of a problem than encoding. However, 17 of the 21 schizophrenia subjects scored one standard score or more above the mean for false positives on the recognition task. Thus, it is questionable to assume a retrieval problem for schizophrenia subjects given the high number of false positives for the majority of that group. A better hypothesis might be that the high number of false positives on the recognition task may be evidence for the schizophrenia subjects having discrimination difficulties between target and distractor items, and/or a "yes" response bias which may be a form of perseveration.

Significant differences were found between each of the three groups on both immediate and delayed logical verbal memory on the raw scores. However, when percentile scores, which take into account age differences, were analyzed, the two patient groups had significantly more logical verbal memory problems than the normal
group but the schizophrenia and bipolar groups were not significantly different from each other. A retention score was calculated to assist in determining the amount of information retained based on each subject's immediate memory score as compared to the subject's delayed memory score. Both patient groups were again significantly different from the normal group but not from each other. These findings suggest that the schizophrenia and the bipolar groups have significant problems retaining or retrieving information that was originally encoded as compared to normal subjects.

On the figural memory test, significant differences were found among the groups only on the delayed memory score, when educational and intellectual levels were controlled. In follow-up analyses, the schizophrenia and the bipolar groups, had significantly worse copy scores and delayed figural memory scores as compared to the normal group. However, the patient groups were not significantly different from each other. Thus, the patient groups had more difficulty on the visual-spatial constructional tasks which may have confounded the memory results. Future research needs to examine nonverbal memory functioning with tests that do not require construction. Also, in the future, approach to the visual-spatial task should be measured as it appears that the normal subjects tended to draw the framework i.e. large rectangle, and then draw the smaller parts. In contrast, the drawings of the schizophrenia subjects tended to be more fragmented, perhaps never really perceiving the gestalt. This observation needs to be quantified.
The effects of medication may hinder performance on neuropsychological tests. Medication may cause psychomotor slowing which may influence test performance. Golden (1978) specifically cautions about this confounding variable on the Stroop.

With regards to bipolar disorder, these subjects tended to have significant difficulty on the variables of frontal lobe function as compared to normal subjects. The dysfunction of the bipolar subjects though was not to the extent of the subjects with schizophrenia (total verbal fluency, mental flexibility - Trails B, shifting cognitive sets and perseveration - WCST). One exception was the Interference score on the Stroop where the patient groups were not significantly different.

Verbal learning and memory for a list of words for bipolar subjects was difficult and significantly lower than normal subjects. Again however, verbal learning and memory was not as impaired as for schizophrenia patients. In follow-up analyses, the bipolar group scored significantly lower than normal subjects on the recognition task of a verbal memory test. This score suggests that bipolar patients may have difficulty discriminating between target and distractor items.

Logical verbal memory, immediate and delayed, was significantly impaired for the bipolar group as compared to the normal group. However, the memory deficits were not significantly different from the schizophrenia group when percentile scores were analyzed. The percentile scores are based on age related normative data. Also, when comparing immediate to delayed verbal memory, the bipolar subjects appear to retain significantly less of the stories
than normal subjects. On a nonverbal memory task, the bipolar group had significantly more difficulties than the normal group but again was not significantly different from the schizophrenia group. Thus, both verbal and nonverbal memory functions appear impaired for bipolar patients. However, the impairment was less severe than for schizophrenia patients on one verbal learning and memory task.

In summary, the current study found significant differences among the schizophrenia, bipolar, and normal groups. Significant differences continued to be found among the groups, with the exception of the interference score, even when education and intellectual level are covariates. Thus, the differences are more than just a reflection of lower educational and lower intellectual level, which in itself may be affected by the disease process. The differences between the groups suggest that the schizophrenia subjects have more difficulty than normals on frontal and temporal lobe functions. The schizophrenia group also appears more impaired than the bipolar group on these functions with the exception of the delayed logical verbal memory and delayed figural memory tasks, as well as the interference score. The current study adds confirmation and clarification of frontal and temporal lobe dysfunction in persons with schizophrenia. Further research is needed in examining ways in which cognitive dysfunction affects daily living skills and the rehabilitation process.
APPENDIX A

TABLES
Table 1

Demographic Characteristics for Schizophrenic, Bipolar, and Normal Subjects

<table>
<thead>
<tr>
<th></th>
<th>Patients with Schizophrenia</th>
<th>Patients with Bipolar Disorder</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>38.05 ± 8.22 21</td>
<td>39.00 ± 9.97 20</td>
<td>32.45 ± 7.06 20</td>
</tr>
<tr>
<td>Education (years)</td>
<td>10.67 ± 1.39 21</td>
<td>12.70 ± 2.70 20</td>
<td>14.30 ± 2.58 20</td>
</tr>
<tr>
<td>Yrs. since 1st hospitalization</td>
<td>13.00 ± 7.82 21</td>
<td>11.88 ± 7.89 17</td>
<td>-</td>
</tr>
<tr>
<td>Age at onset</td>
<td>20.65 ± 6.93 20</td>
<td>23.29 ± 9.20 17</td>
<td>-</td>
</tr>
<tr>
<td>Education at onset</td>
<td>10.47 ± 1.90 19</td>
<td>12.50 ± 2.88 10</td>
<td>-</td>
</tr>
</tbody>
</table>


Table 2

Mean Performances for Schizophrenic, Bipolar, and Normal Subjects on Tests of Neuropsychological Functioning

<table>
<thead>
<tr>
<th>Test</th>
<th>Patients with Schizophrenia</th>
<th>Patients with Bipolar Disorder</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Controlled Oral Word Assoc. - Total</td>
<td>19.10</td>
<td>7.83</td>
<td>30.50</td>
</tr>
<tr>
<td>Stroop - Interference T Score</td>
<td>45.24</td>
<td>6.62</td>
<td>47.60</td>
</tr>
<tr>
<td>Trail Making B Time T Score</td>
<td>19.24</td>
<td>9.43</td>
<td>38.40</td>
</tr>
<tr>
<td>WCST Number of Categories</td>
<td>1.86</td>
<td>1.20</td>
<td>3.60</td>
</tr>
<tr>
<td>WCST Perseverative Errors</td>
<td>48.67</td>
<td>21.71</td>
<td>28.65</td>
</tr>
<tr>
<td>CVLT Long Delayed Free Recall</td>
<td>5.10</td>
<td>2.55</td>
<td>8.05</td>
</tr>
<tr>
<td>WMS-R Delayed Memory Percentile</td>
<td>12.14</td>
<td>11.55</td>
<td>18.50</td>
</tr>
<tr>
<td>Rey-Osterreith Figure Delayed Memory</td>
<td>4.88</td>
<td>4.09</td>
<td>6.95</td>
</tr>
</tbody>
</table>

Note. Schizophrenia Group (N=21); Bipolar Group (N=20); Normal Group (N=20).
WCST=Wisconsin Card Sorting test, CVLT=California Verbal Learning Test, WMS-R=Wechsler Memory Scale-Revised.
Table 3

Mean Performances for Schizophrenic, Bipolar, and Normal Subjects on Test of Intellectual Functioning

<table>
<thead>
<tr>
<th>Test Battery</th>
<th>Patients with Schizophrenia</th>
<th>Patients with Bipolar Disorder</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>KBIT - Vocabulary Standard Score</td>
<td>77.00</td>
<td>11.77</td>
<td>94.65</td>
</tr>
<tr>
<td>KBIT - Matrices Standard Score</td>
<td>75.24</td>
<td>13.92</td>
<td>90.40</td>
</tr>
<tr>
<td>KBIT - Composite IQ</td>
<td>73.48</td>
<td>11.97</td>
<td>91.75</td>
</tr>
</tbody>
</table>

Note. Schizophrenia Group (N=21); Bipolar Group (N=20); Normal Group (N=20). KBIT=Kaufman Brief Intelligence Test.
### Table 4

Mean Performances for Schizophrenic, Bipolar, and Normal Subjects on Wisconsin Card Sorting Test

<table>
<thead>
<tr>
<th>Category</th>
<th>Patients with Schizophrenia</th>
<th>Patients with Bipolar Disorder</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Categories</td>
<td>1.86</td>
<td>1.20</td>
<td>3.60</td>
</tr>
<tr>
<td>Perseverative Responses</td>
<td>59.81</td>
<td>29.79</td>
<td>34.55</td>
</tr>
<tr>
<td>Perseverative Errors</td>
<td>48.67</td>
<td>21.71</td>
<td>28.65</td>
</tr>
<tr>
<td>Percent Perseverative Errors</td>
<td>58.57</td>
<td>97.31</td>
<td>23.55</td>
</tr>
<tr>
<td>Trials to First Category</td>
<td>21.67</td>
<td>23.92</td>
<td>22.35</td>
</tr>
<tr>
<td>Percent Conceptual Responses</td>
<td>29.71</td>
<td>16.25</td>
<td>47.85</td>
</tr>
<tr>
<td>Failure to Maintain Set</td>
<td>1.10</td>
<td>1.76</td>
<td>0.75</td>
</tr>
</tbody>
</table>

**Note.** Schizophrenia Group (N=21); Bipolar Group (N=20); Normal Group (N=20).
Table 5

Mean Performances for Schizophrenic, Bipolar, and Normal Subjects on Trail Making Tests A and B

<table>
<thead>
<tr>
<th></th>
<th>Patients with Schizophrenia</th>
<th>Patients with Bipolar Disorder</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Trail Making A Time – Seconds</td>
<td>66.90</td>
<td>35.96</td>
<td>40.30</td>
</tr>
<tr>
<td>Trail Making A Time T</td>
<td>29.29</td>
<td>11.15</td>
<td>43.10</td>
</tr>
<tr>
<td>Trail Making B Time – Seconds</td>
<td>259.43</td>
<td>75.49</td>
<td>136.45</td>
</tr>
<tr>
<td>Trail Making B Time T</td>
<td>19.24</td>
<td>9.43</td>
<td>38.40</td>
</tr>
</tbody>
</table>

Note. Schizophrenia Group (N=21); Bipolar Group (N=20); Normal Group (N=20).
Table 6

Mean Performances for Schizophrenic, Bipolar, and Normal Subjects on Controlled Oral Word Association

<table>
<thead>
<tr>
<th></th>
<th>Patients with Schizophrenia</th>
<th>Patients with Bipolar Disorder</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>COWA F</td>
<td>6.95</td>
<td>3.34</td>
<td>10.80</td>
</tr>
<tr>
<td>COWA A</td>
<td>4.95</td>
<td>2.38</td>
<td>8.90</td>
</tr>
<tr>
<td>COWA S</td>
<td>7.19</td>
<td>2.79</td>
<td>10.80</td>
</tr>
<tr>
<td>COWA Perseverations</td>
<td>0.67</td>
<td>1.02</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Note. Schizophrenia Group (N=21); Bipolar Group (N=20); Normal Group (N=20).
### Table 7

**Mean Performances for Schizophrenic, Bipolar, and Normal Subjects on Stroop**

<table>
<thead>
<tr>
<th></th>
<th>Patients with Schizophrenia</th>
<th>Patients with Bipolar Disorder</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Stroop Word</td>
<td>66.33</td>
<td>17.07</td>
<td>90.05</td>
</tr>
<tr>
<td>Stroop Word T</td>
<td>29.43</td>
<td>8.50</td>
<td>41.30</td>
</tr>
<tr>
<td>Stroop Color</td>
<td>44.24</td>
<td>10.61</td>
<td>60.15</td>
</tr>
<tr>
<td>Stroop Color T</td>
<td>26.43</td>
<td>7.05</td>
<td>37.10</td>
</tr>
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<td>Stroop Color Word</td>
<td>21.90</td>
<td>8.36</td>
<td>33.60</td>
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<tr>
<td>Stroop Color Word T</td>
<td>25.95</td>
<td>9.01</td>
<td>38.65</td>
</tr>
<tr>
<td>Stroop Interference</td>
<td>-4.76</td>
<td>6.62</td>
<td>-2.35</td>
</tr>
<tr>
<td>Stroop Interference T</td>
<td>45.24</td>
<td>6.62</td>
<td>47.60</td>
</tr>
</tbody>
</table>

*Note.* Schizophrenia Group (N=21); Bipolar Group (N=20); Normal Group (N=20).
Table 8

Mean Performances for Schizophrenic, Bipolar, and Normal Subjects on California Verbal Learning Test

<table>
<thead>
<tr>
<th></th>
<th>Patients with Schizophrenia</th>
<th>Patients with Bipolar Disorder</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>List A Trials 1-5 Tot Std. Score</td>
<td>12.67</td>
<td>9.16</td>
<td>26.30</td>
</tr>
<tr>
<td>List A Short-Delay Free Recall</td>
<td>5.38</td>
<td>3.47</td>
<td>7.95</td>
</tr>
<tr>
<td>List A Short-Delay Cued Recall</td>
<td>6.24</td>
<td>3.19</td>
<td>9.15</td>
</tr>
<tr>
<td>List A Long-Delay Free Recall</td>
<td>5.10</td>
<td>2.55</td>
<td>8.05</td>
</tr>
<tr>
<td>List A Long-Delay Cued Recall</td>
<td>6.10</td>
<td>2.55</td>
<td>8.60</td>
</tr>
<tr>
<td>Recognition Hits</td>
<td>13.67</td>
<td>1.91</td>
<td>12.85</td>
</tr>
<tr>
<td>Short-Delay Free Recall</td>
<td>-35.14</td>
<td>30.34</td>
<td>-20.70</td>
</tr>
<tr>
<td>Compared to List A Trial 5</td>
<td>38.57</td>
<td>128.56</td>
<td>1.40</td>
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<tr>
<td>Long-Delay Free Recall Compared to Short-Delay Free Recall</td>
<td>271.10</td>
<td>338.55</td>
<td>75.35</td>
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<tr>
<td>Recognition Hits Compared to Long-Delay Free Recall</td>
<td>5.62</td>
<td>5.86</td>
<td>4.75</td>
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</table>

Note. Schizophrenia Group (N=21); Bipolar Group (N=20); Normal Group (N=20).
Table 9

Mean Performances for Schizophrenic, Bipolar, and Normal Subjects on Logical Verbal Memory Subtest of Weschler Memory Scale—Revised

<table>
<thead>
<tr>
<th></th>
<th>Patients with Schizophrenia</th>
<th>Patients with Bipolar Disorder</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Immediate Logical Verbal Sum</td>
<td>12.14</td>
<td>6.02</td>
<td>20.75</td>
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<tr>
<td>Immediate Logical Verbal Percentile</td>
<td>10.24</td>
<td>11.27</td>
<td>22.40</td>
</tr>
<tr>
<td>Delayed Logical Verbal Sum</td>
<td>9.00</td>
<td>5.77</td>
<td>15.65</td>
</tr>
<tr>
<td>Delayed Logical Verbal Percentile</td>
<td>12.14</td>
<td>11.55</td>
<td>18.50</td>
</tr>
<tr>
<td>Percent Retention</td>
<td>69.29</td>
<td>27.42</td>
<td>72.05</td>
</tr>
</tbody>
</table>

Note. Schizophrenia Group (N=21); Bipolar Group (N=20); Normal Group (N=20).
<table>
<thead>
<tr>
<th></th>
<th>Patients with Schizophrenia</th>
<th>Patients with Bipolar Disorder</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure Copy Score</td>
<td>17.17</td>
<td>22.08</td>
<td>28.90</td>
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<tr>
<td></td>
<td>8.79</td>
<td>9.96</td>
<td>4.28</td>
</tr>
<tr>
<td>Delayed Figural Memory</td>
<td>4.88</td>
<td>6.95</td>
<td>15.73</td>
</tr>
<tr>
<td></td>
<td>4.09</td>
<td>5.27</td>
<td>6.03</td>
</tr>
</tbody>
</table>

*Note.* Schizophrenia Group (N=21); Bipolar Group (N=20); Normal Group (N=20).
APPENDIX B

INFORMED CONSENT FORMS
INFORMED CONSENT FORM

NAME OF RESEARCH PROJECT: The Assessment of Cognitive Functioning in Persons with Mental Disorders: Identification of Neuropsychological Markers

PURPOSE OF THIS RESEARCH: This study will help identify your current level of functioning. It will help identify the tests which most accurately assess your functioning. This kind of information would be helpful in developing appropriate services for patients.

WHAT YOU WILL DO IF YOU ARE IN THIS RESEARCH: (1) You will be asked to respond to questionnaires, verbally and in writing. You will be given activities with geometric designs, shapes, to complete. It should take about one and a half to two and a half hours to complete, during one session. There will be a five minute break in the middle. (2) Also, the researcher will gain demographic and past assessment information from your medical file, i.e., length of hospitalization, history of head injury or major medical concern, diagnosis, medications, etc. (3) The researcher will have persons on your treatment team rate your symptoms and functional abilities.

BENEFITS: The information obtained from this study can be used to supplement your medical records and there will be no charges or additional fees incurred as a result of patient involvement in this study. Also, this information may be added to your medical records to assist the treatment team in rehabilitation planning if you check yes on the consent form. When all of the activities are completed, you will receive five dollars.

RISKS OF HARM: There are no personal risks or discomfort directly involved with this research.
CHOOSING NOT TO PARTICIPATE OR DROPPING OUT OF THE RESEARCH STUDY: Participation is voluntary. You are free to withdraw your consent at any time. A decision to not participate or to withdraw from the study will not affect the services available to you at Terrell State Hospital.

CONFIDENTIALITY: Any information obtained in this study will be recorded with a code number to ensure that all information remains anonymous. At the completion of the study, the key that relates to the identity of each participant will be destroyed to safeguard confidentiality concerns. Under this condition, information obtained from this research may be used in any way thought best for publication and education.

ANSWERS TO ADDITIONAL QUESTIONS: If you have any questions before, during, or after your involvement in this research project, you may contact Janice Hall, M.S. or Ernest Harrell Ph.D. at (817) 565-2671, University of North Texas, Denton, Texas. You may also contact John Skinner, Ph.D. at Terrell State Hospital, Psychosocial Rehabilitation Unit, at (214) 563-6452.
You may consult with a member of the Internal Review Board, IRB, at any time concerning your treatment and welfare by calling the IRB chairman at Terrell State Hospital (Dr. Carroll Hughes, 214-563-6452 Ext. 2592). You may consult with a member of the public responsibility committee at any time concerning your treatment and welfare. The public responsibility committee is a group of volunteers who work to protect the rights and interests of clients.
Certificate of person giving consent:

I understand each of the above items relating to the participation of ______________________ in the research of the Assessment of Cognitive Functioning in Psychiatric Patients under the care of Janice Hall and I hereby agree to my participation in the research project.

______________________________     ________________
Signature of Subject             Date

The information regarding my individual functioning, as obtained in this study, may be given to the treatment team and/or added to my medical records.

_____Yes, I agree.

_____No, I do not agree.

______________________________
Signature of Subject

Certification of person explaining proposal
I have explained the above items to ______________________ and believe that ________ understands each of the items.

______________________________     ________________
Investigator's Signature         Date

THIS PROJECT HAS BEEN REVIEWED BY UNIVERSITY OF NORTH TEXAS COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (Phone: 817-565-3946).
INFORMED CONSENT FORM

Normal Control Group

NAME OF RESEARCH PROJECT: The Assessment of Cognitive Functioning in Persons with Mental Disorders: Identification of Neuropsychological Markers

PURPOSE OF THIS RESEARCH: This study will help identify the tests which most accurately assess cognitive functioning in persons with mental disorders. This kind of information would be helpful in developing appropriate services for patients.

WHAT YOU WILL DO IF YOU ARE IN THIS RESEARCH: (1) You will be asked to respond to questionnaires, verbally and in writing. You will be given activities with geometric designs, shapes, to complete. It should take about one and a half to two and a half hours to complete, during one session. There will be a five minute break in the middle. (2) Also, the researcher will ask for demographic information i.e., education, history of head injury or major medical concerns, medications, etc.

BENEFITS: The information obtained from this study will be helpful in the assessment and treatment of persons with mental disorders. When all of the activities are completed, you will receive five dollars.

RISKS OF HARM: There are no personal risks or discomfort directly involved with this research.

CHOOSING NOT TO PARTICIPATE OR DROPPING OUT OF THE RESEARCH STUDY: Participation is voluntary. You are free to withdraw your consent at any time. A decision to not participate or to withdraw from the study will not affect your relationship with Terrell State Hospital.
CONFIDENTIALITY: Any information obtained in this study will be recorded with a code number to ensure that all information remains anonymous. At the completion of the study, the key that relates to the identity of each participant will be destroyed to safeguard confidentiality concerns. Under this condition, information obtained from this research may be used in any way thought best for publication and education.

ANSWERS TO ADDITIONAL QUESTIONS: If you have any questions before, during, or after your involvement in this research project, you may contact Janice Hall, M.S. or Ernest Harrell Ph.D. at (817) 565-2671, University of North Texas, Denton, Texas. You may also contact John Skinner, Ph.D. at Terrell State Hospital, Psychosocial Rehabilitation Unit, at (214) 563-6452. You may consult with a member of the Internal Review Board, IRB, at any time concerning your treatment and welfare by calling the IRB chairman at Terrell State Hospital (Dr. Carroll Hughes, 214-512-563-6452). You may consult with a member of the public responsibility committee at any time concerning your treatment and welfare. The public responsibility committee is a group of volunteers who work to protect the rights and interests of clients.

Certificate of person giving consent:

I understand each of the above items relating to the participation of ______________________ in the research of the Assessment of Cognitive Functioning in Psychiatric Patients under the care of Janice Hall and I hereby agree to my participation in the research project.

_________________________________________  _____________
Signature of Subject                  Date
Certification of person explaining proposal

I have explained the above items to ______________________

and believe that _______ understands each of the items.

_____________________________  ______________________
Investigator's Signature        Date

THIS PROJECT HAS BEEN REVIEWED BY UNIVERSITY OF NORTH TEXAS COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (Phone: 817-565-3946).
REFERENCES


further evidence for regional and behavioral specificity. Archives of General Psychiatry, 45, 616-622.


and Experimental Neuropsychology. 12, 55-56, (Abstract from 18th Annual Meeting).


