INFORMATION PROCESSING IN SCHIZOPHRENIA AND BIPOLAR DISORDER: A DISCRIMINANT ANALYSIS STUDY

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

Wai-Cheong Carl Tam, B.S., M.S.
Denton, Texas
August, 1995

INFORMATION PROCESSING IN SCHIZOPHRENIA AND BIPOLAR DISORDER: A DISCRIMINANT ANALYSIS STUDY

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

Wai-Cheong Carl Tam, B.S., M.S.
Denton, Texas
August, 1995

Tam, Wai-Cheong Carl. Information Processing in Schizophrenia and Bipolar Disorder: A Discriminant Analysis Study. Doctor of Philosophy (Clinical Psychology), August, 1995, 70 pp., 19 tables, 5 illustrations, references, 67 titles.

Schizophrenia and bipolar disorder are two distinct categories of mental disorders in the DSM-IV. However, it is sometimes difficult to make a differential diagnosis between the two because of the overlapping symptoms. One of the approaches for classification of schizophrenia and bipolar disorder is by means of information processing models, as patients with schizophrenia and possibly those with bipolar disorder appear to have information processing deficits. A study was conducted in which a computerized battery of information processing tasks (called the COGLAB) was administered to three subject groups: patients with schizophrenia, patients with bipolar disorder, and normal controls. The tasks included Mueller-Lyer illusion, reaction time, size estimation, Wisconsin Card Sort, backward masking, and Asarnow Continuous Performance. Discriminant analysis was used to investigate the differences among the three groups. Results indicated that the COGLAB correctly classified 75.5% of the cases of schizophrenia and bipolar disorder. The results of univariate ANOVAs showed that

Mueller-Lyer illusion and the number of perseverative errors of Wisconsin Card Sort manifested significant differences between the two groups. The implications and limitations of this study are also discussed.

ACKNOWLEDGMENTS

The author would like to thank the following persons for their generous help with data collection: Dr. Hwei-Chuang Deng and Ms. Wei-Mei Ho of the Taipei City Psychiatric Center, Mr. Cheoc-Seng Lio, and Ms. Tan-Jung Cheng.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF ILLUSTRATIONS

CHAPTER I

INTRODUCTION

Due to the rapid advancement of sophisticated computerized technologies, there is an increasing interest in researching the information processing of human beings. This often requires precise control of visual or auditory stimuli of very short duration (in the range of milliseconds) easily accomplished with computers. The models of information processing assume that stimuli impinging on organisms can be divided into a progressive series of stages or steps (Braff, 1991; Solso, 1988). By understanding how information is being processed in the brain, similarities and differences of individual human cognitive functioning can be revealed.

Patients with mental disorders, such as schizophrenia, have been known to have information processing deficits (Levin, Yurgelun-Todd, & Craft, 1989; Nuechterlein & Dawson, 1984). Some researchers, such as Callaway and Naghdi (1982) and Carr and Wale (1986), have proposed information processing models for schizophrenia. Rund and Landrø (1990) remarked that information processing deficits can be found in psychiatric syndromes other than schizophrenia, especially in mania.

In the following sections, the classification problems in schizophrenia and bipolar (also known as manic-depressive or manic) disorder and the possibility of solving this problem by using information processing models are discussed. A battery of information processing tasks (called the COGLAB) was administered to patients with schizophrenia and bipolar disorder as well as to normal controls. The results and implications of this study are also discussed.

Classification Problems in Schizophrenia and Bipolar Disorder

In clinical settings, mental health personnel generally use the DSM (Diagnostic and Statistical Manual of Mental Disorders) system of classification of mental disorders. In the DSM-IV (American Psychiatric Association, 1994), schizophrenia and bipolar disorders are two distinct categories of mental disorders. However, it is stated that the differential diagnosis of schizophrenia from "Mood Disorder with Psychotic Features ... is made difficult by the fact that mood disturbance is common during the prodromal, active, and residual phases of Schizophrenia" (p. 283). Keller and Baker (1991) remarked that the diagnosis of bipolar disorder can be complicated by the apparent symptomatic overlap with other psychiatric disorders. Some research has tried to clarify the diagnostic distinction

between schizophrenia and affective or mood disorders--particularly bipolar disorder (Magaro, 1984a).

Kendell and Gourlay (1970) analyzed the clinical data of 146 patients with schizophrenia and 146 patients with affective psychoses by applying discriminant function analysis on 38 variables. They concluded that "the distribution of the weighted scores of the 292 patients on the discriminant function differed significantly from a normal distribution, but the distribution was trimodal rather than bimodal" (p. 265). Thus no definite conclusions could be drawn on whether schizophrenia and affective psychoses are one or two distinct categories of disorders.

Pope and Lipinski (1978) reviewed the differential diagnosis between schizophrenia and bipolar disorder. They concluded that most so-called schizophrenic symptoms have little demonstrated validity in determining diagnosis, prognosis, or treatment response in psychosis. They estimated that in about 20% to 50% of well validated cases of bipolar disorder, classical schizophrenic symptoms are present, including many types of hallucinations, delusions, catatonic symptoms, and Schneiderian first-rank symptoms.

Brockington, Kendell, Wainwright, Hillier, and Walker (1979) carried out discriminant function analyses with history, mental state, and follow-up data in two samples of patients. A bimodal distribution of discriminant scores was

obtained for the sample consisting of 128 general psychotic patients (36 with schizophrenia and 43 with affective sychosis), but the distribution was ambiguous for the other sample consisting of 106 schizoaffective patients (35 were also later diagnosed with schizophrenia and 47 with affective psychosis). The authors concluded that the results are far from ideal in demonstrating a dichotomy between schizophrenia and affective psychoses.

Kendell and Brockington (1980) analyzed the relation between symptomatology and various indices of outcome in two samples. The first sample consisted of 127 patients with functional psychoses including schizophrenia, paranoia, and affective disorders. The second sample consisted of 105 patients exhibiting a mixture of affective and schizophrenic or paranoid sypmtoms. The authors described a method for identifying a genuine boundary between related syndromes, if one exists, by demonstrating a non-linear relation between symptomatology and outcome. They reported that a non-linear relation could not be demonstrated between symptomatology and outcome in these two samples, concluding that the putative boundary between schizophrenia and affective psychoses cannot be established.

Crow (1984, 1986) reviewed the research on functional psychoses and came up with three observations. First, a bimodal distribution of the clinical features of bipolar

disorder and schizophrenia has not been demonstrated. Second, the similarity of season of birth (cf. Tam & Sewell, 1995) and season of onset effects (cf. Hare & Walter, 1978) may suggest that the psychoses share etiological determinants. Third, regarding family studies, affective disorder appears to predispose to schizophrenia in later generations; and studies of schizoaffective disorder have failed to separate this entity from either affective disorder or schizophrenia. Crow proposed that psychosis might be a continuum extending from unipolar, through bipolar affective disorder and schizoaffective disorder, to typical schizophrenia.

Hoff et al. (1990) compared the scores of a group of neuropsychological measures between 30 inpatients with schizophrenia and 35 with bipolar disorder, manic type. The measures included Wechsler Adult Intelligence Scale-Revised, Wechsler Memory Scale, California Verbal Learning Test, Benton Visual Retention Test, Hooper Visual Organization Test, Ravens Colored Progressive Matrices, Trailmaking A and B, Symbol Digit Modalities Test, and Purdue Pegboard Test. Separate factor analyses were performed on measures of verbal, spatial, and speed variables in order to generate summary scales. The authors concluded that there were no significant differences between the two groups of patients on the three factors (verbal, spatial, and speed) or on

individual test variables after controlling the effects of age, education, sex, duration of illness, number of previous hospitalizations, and medications at time of testing.

Brockington et al. (1991) conducted discriminant and canonical analyses on the ratings of lifetime psychopathology and course of illness of 302 psychiatric patients diagnosed with either schizophrenia, bipolar disorder, or major depression. The authors concluded that bipolar disorder emerged as a distinct grouping, and the remaining patients formed a "schizodepressive continuum" (p. 485).

Murray, O'Callaghan, Castle, and Lewis (1992) reviewed the research on the distinction between schizophrenia and bipolar disorder. They concluded that the conventional distinction between the disorders has received little objective support from studies of phenomenology, outcomes, or familial homotypy. However, they disagreed that schizophrenia and bipoar disorder are a single disorder lying along a continuum with a single etiology. They distinguish congenital schizophrenia from adult-onset schizophrenia. The former was described as a consequence of aberrant brain development during fetal and neonatal life. The latter was characterized as a heterogeneous, relapsing, and remitting disorder that is more frequent in females than

in males, exhibits positive but not negative sypmtoms, and has much in common etiologically with affective psychosis.

It appears that no definite conclusions can be drawn from the above literature regarding the classification problems in schizophrenia and bipolar disorder. Besides the lack of distinct boundary between schizophrenia and bipolar disorder, these two disorders can each be classified into different subtypes. This heterogeneity of schizophrenia and bipolar disorder further complicates their differential diagnosis.

In the DSM-IV, schizophrenia is divided into five subtypes: catatonic, disorganized, paranoid, undifferentiated, and residual. Although not in DSM-IV, schizophrenia can also be divided into other different subtypes depending on the dimensions used for classification (Magaro, 1984b). For example, schizophrenia can be subdivided into paranoid versus nonparanoid, good versus poor premorbid adjustments, or reactive versus process on course of illness (Magaro, 1984a). Walker, Harvey, and Perlman (1988) have supported the positive/negative symptom distinction in schizophrenia as subtypes. Finally Hsu (1990) administered a modified stroop test to 125 schizophrenic patients and suggested four subtypes based on their reaction times.

Bipolar disorder is commonly subdivided into bipolar I and bipolar II disorders (Silverstone & Romans-Clarkson, 1989); the DSM-IV has adopted this classification. Bipolar I isorder indicates a manic episode has occured, whereas bipolar II disorder has hypomania only. In addition, disorders with bipolar features that do not meet the criteria for any specific bipolar disorders are diagnosed as bipolar disorder not otherwise specified. Klerman (1981, 1987) has suggested even further subtyping of bipolar disorder into bipolar III (cyclothymic personality), IV (hypomania or mania precipitated by antidepressant drugs), V (depressed patients with bipolar relatives), and VI (mania without depression).

From the above literature review, it can be seen that a clear-cut boundary cannot be established between schizophrenia and bipolar disorder regarding symptoms, family medical history, and outcome measures. Thus further research is needed to help with the differential diagnosis between these two disorders.

Information Processing Models

One of the potentially useful approaches for classification of schizophrenia and bipolar disorder is by means of information processing models. Patients with schizophrenia and possibly those with bipolar disorder appear to have information processing deficits (Carr & Wale,

1986). Braff (1991) proposed that physiological or neurochemical anomalies might underlie information processing abnormalities of these disorders.

The main neuropsychological findings on schizophrenia include disturbances in regional cerebral blood flow with left hemisphere hyperactivity, enlarged ventricles, cerebral atrophy, hypofrontality of glucose metabolism, and decrease in the size of amygdala (Beramn, Zec, & Weinberger, 1986; Kirkpatrick & Buchanan, 1990; Mirsky and Duncan, 1986; Paulman et al., 1990). It has been hypothesized that schizophrenia is a neurodevelopmental disorder in which there are brain lesions during the fetal and/or perinatal period (Lyon, Barr, Cannon, Mednick, & Shore, 1989; Weinberger, 1987). Posner and Nakagarva (1989) postulated that there is a specific deficit in computations within the anterior attentional circuitry of the brain. These neuropsychological findings may affect the information processing of schizophrenic patients.

A general information processing model is shown in Figure 1. Callaway and Naghdi (1982) proposed an information processing model for schizophrenia saying that schizophrenics have a defect in controlled serial processes, but not in automatic parallel processes. Another model is proposed by Carr and Wale (1986), who hypothesized that the deficits in the perception of information in schizophrenia

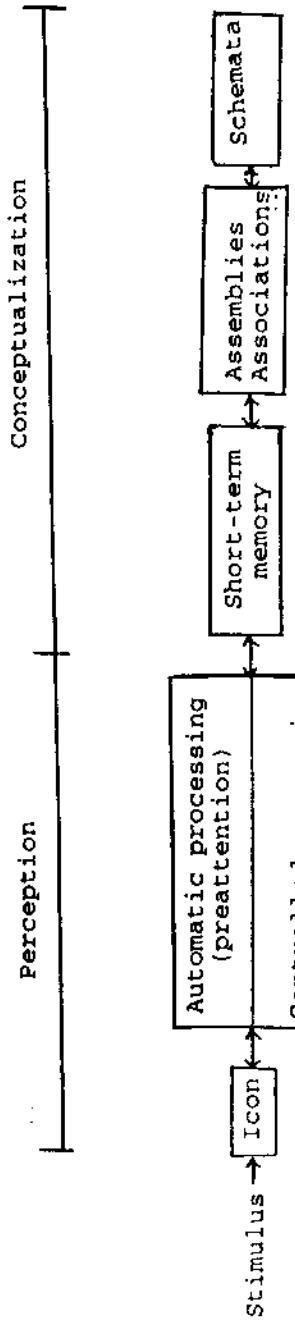


Figure 1. A general information processing model.

(Adapted from Magaro, 1984a, p. 178)

are related to dysfunction at the level of preattentive processes.

Although there is less research on bipolar disorder than schizophrenia, there are still some neuropsychological findings regarding this disorder. Brown et al. (1986) compared the structural brain differences in 41 patients with schizophrenia and 29 with affective disorder. They found that the brains of the patients with schizophrenia were 6% lighter, the anterior and temporal horn of the lateral ventricle were larger by 19% and 97% respectively, and the parahippocampal cortices were thinner by 11%. Swayze II, Andreasen, Alliger, Ehrhardt, and Yuh (1990) examined the structural brain abnormalities of 48 patients with bipolar disorder, 54 with schizophrenia, and 47 normal controls. They concluded that there was a trend of lateral ventricular enlargement in male bipolar patients. Moreover, patients of bipolar disorder with focal signal hyperintensities had a trend toward larger ventricular size compared to those without. In spite of the lack of information processing models proposed for bipolar disorder, patients with bipolar disorder have shown to have deficits in some of the information processing tasks which are discussed in the following section.

Information Processing Tasks

After reviewing the research on the information processing deficits in schizophrenia, Chapman and Chapman (1973) suggested that a single measurement is not sufficient to assess a specific cognitive deficit because subjects with cognitive pathology often show generalized cognitive deficit. Thus differential deficit, a greater loss in one ability than in one or more other abilities, should be studied. Knight (1984) also commented that in order to obtain convincing evidence for a specific information processing model for schizophrenia, "both schizophrenics and controls must achieve a predicted pattern of performance either across the levels of a well-validated task or across a number of theoretically integrated tasks that have been shown to tap various components of a process" (p. 127). This is necessary because some of the information processing deficits in schizophrenia are also present in other mental disorders, and there may exist alternative explanations for any one particular deficit.

A computerized battery of information processing tasks called the COGLAB has been devised by Spaulding and his colleagues (Spaulding, 1989; Spaulding, Garbin, & Crinean, 1989; Spaulding, Hargrove, Crinean, & Martin, 1981). This battery consists of the following tasks: Mueller-Lyer illusion, reaction time (with temporal redundancy and

distraction probes), size estimation, Wisconsin Card Sort (an adaptation of the Wisconsin Card Sorting Test), backward masking, and Asarnow Continuous Performance--a hybridization of the Continuous Performance Test (CPT) and span of apprehension. According to Spaulding (1989), the individual tasks of the COGLAB are selected to represent a continuum of information processing from preattentional (measured by backward masking) to attentional (measured by reaction time tasks and Asarnow Continuous Performance) to conceptual (measured by Wisconsin Card Sort). This battery has been used in a study with 125 chronic schizophrenia patients and 140 college students as controls (Spaulding, Garbin, & Crinean, 1989). The best discriminant function correctly classified 81% of all the subjects. A summary of the research using the individual tasks in the COGLAB with schizophrenic and/or bipolar disorder patients is given below.

Regarding the Mueller-Lyer illusion (two identical line segments appearing to be of different lengths due to contextual cues), there is evidence that good premorbid paranoid schizophrenics are susceptible to the illusion, but chronic nonremitting nonparanoid schizophrenics may have a paradoxical immunity. Generally speaking, schizophrenics as a group are more prone to exaggerate the Mueller-Lyer

illusion (Cromwell & Spaulding, 1978; Spaulding, 1978; Spaulding, Garbin, & Dras, 1989).

Much research has been conducted on the reaction time paradigm among psychiatric patients, especially patients with schizophrenia. A simple reaction-time paradigm is shown in Figure 2. The research on reaction time in schizophrenia has been reviewed by Cromwell and Spaulding (1978), Nuechterlein and Dawson (1984), Spaulding, Garbin, and Dras (1989), Rund and Landrø (1990), and Braff (1991). A commonly found phenomenon on reaction time with schizophrenic patients is known as reaction-time crossover (also known as RAD--redundancy-associated deficit). That is, when the reaction times of both regular and irregular preparatory intervals (PI) are compared (regular PIs mean same PI occurs consecutively and irregular PIs mean different PI occurs consecutively), schizophrenic patients generally tend to be faster with regular PIs only when PIs are short (about 2 to 5 seconds). With longer regular PIs they are slower than with irregular PIs of the same period of time. This is illustrated in Figure 3. It is estimated that a typical reaction-time crossover pattern is manifested in about 50% to 70% of all process schizophrenics (Rund & Landrø, 1990; Spaulding, Huntzinger, LeCompte, & Cromwell, 1984; Strauss, Bohannon, Kaminsky, & Kharabi, 1979). When visual distraction (known as a "probe") is added to the warning

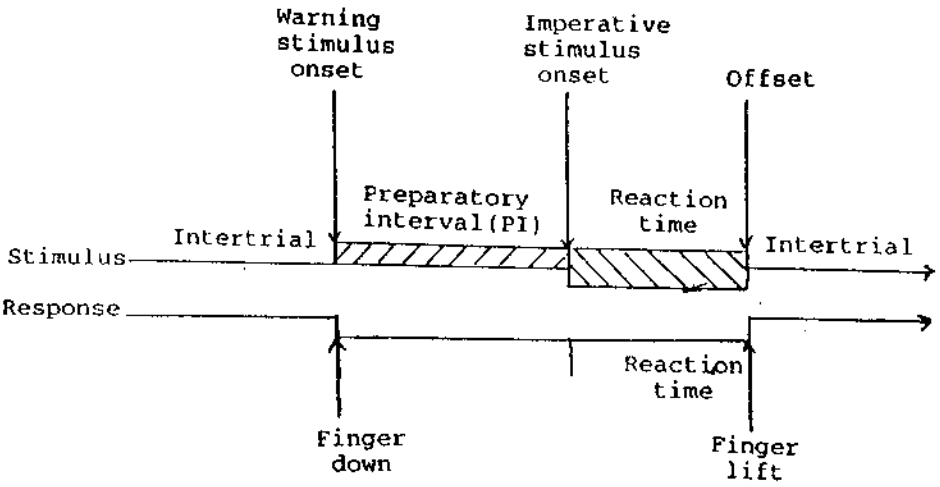


Figure 2. A simple reaction-time paradigm. (Adapted from Cromwell & Spaulding, 1978, p. 138)

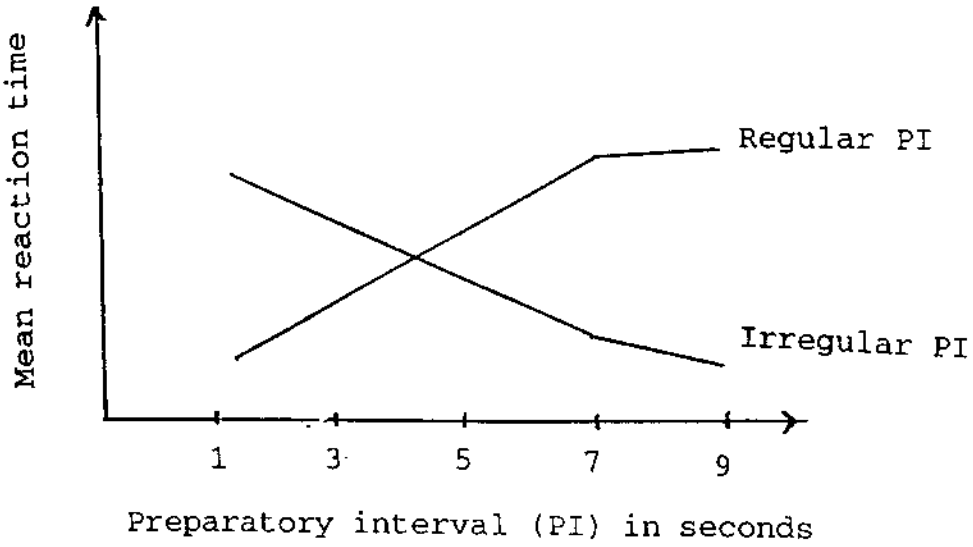


Figure 3. Example of reaction-time crossover for schizophrenic patients.

stimulus, it usually takes longer for the schizophrenics to respond as compared to when the warning stimulus has no probe. Spaulding, Garbin, and Dras (1989) found that process schizophrenics showed more reaction-time impairment at long PIs in the presence of distractors. Miller, Chapman, Chapman, and Kwapil (1993) studied the reaction time of 25 patients with schizophrenia, 14 patients with bipolar disorder, and 69 normal controls. They found a preceding preparatory interval (PPI) effect in all the three groups. This means that reaction times increase when the PI for the immediately preceding trial (the PPI) is longer than the PI for the current trial. However, the schizophrenic group showed the largest PPI effect, and the bipolar subjects did not show a significant difference in the PPI effect compared to both the schizophrenic and control groups.

Regarding size estimation (the comparison of the sizes of figures appearing in two consecutive stimuli), Cromwell and Spaulding (1978) reported that "good premorbid paranoid schizophrenics tend to underestimate and poor premorbid nonparanoid schizophrenics tend to overestimate stimulus size" (p. 146).

The Wisconsin Card Sorting Test (WCST) is a commonly used task to study concept formation in the information processing of subjects (the understanding of some predetermined rules of figure matching). The performance of

patients with schizophrenia on WCST has been reviewed by Levin et al. (1989), Spaulding, Garbin, and Dras (1989), and Rund and Landrø (1990). It is evident that patients with schizophrenia perform significantly worse than normal controls on categories achieved, average number of perseverative responses in categories completed, and total errors. However, the performance of schizophrenics will be improved if they are given reinforcements and detailed instructions (Bellack, Mueser, Morrison, Tierney, & Podell, 1990; Green, Satz, Ganzell, & Vaclav, 1992; Tompkins, Goldman, & Axelrod, 1991). On the other hand, when the WCST has been administered to both schizophrenics and bipolar patients, the two groups have been comparable (Levin et al., 1989). Morice (1990) administered the WCST to 60 schizophrenics, 20 bipolar patients, and 34 normal controls. The author concluded that both the schizophrenics and bipolar patients demonstrated poor performance.

Another information processing task commonly used is backward masking, in which two brief stimuli are presented in rapid succession to determine the effect of the second stimulus (the mask) on the perception of the first (the target). The results of this task with schizophrenia subjects have been reviewed by Nuechterlein and Dawson (1984), Schuck and Lee (1989), Rund and Landrø (1990), and Braff (1991). It has been shown that schizophrenics have

deficits in backward masking compared to normal controls. Saccuzzo and Braff (1981) compared the performance of backward masking between 8 good-prognosis and 8 poor-prognosis schizophrenics. Results indicated that the poor-prognosis schizophrenics showed significant deficits relative to the good-prognosis schizophrenics and normal controls. Saccuzzo and Braff (1986) and Rund (1993) studied the performance of backward masking on schizophrenia and bipolar disorder. Both schizophrenics and bipolar patients had significant deficits compared to normal controls. Green and Walker (1986a) studied the performance of backward masking with five groups of subjects: 12 schizophrenics with positive symptoms, 11 schizophrenics with negative symptoms, 20 schizophrenics with mixed symptoms, 15 bipolar patients, and 12 normal controls. Using critical interstimulus interval as the dependent variable, they found that the schizophrenic patients with mixed symptoms required significantly longer interstimulus interval than did the normal control subjects. However, schizophrenic and bipolar groups did not differ significantly.

The Continuous Performance Test (CPT) is a vigilance test. The simplest version of this test consists of an instruction to press a button each time a predesignated target stimulus occurs on a screen in a random series of stimuli. The performance of schizophrenics on this task has

been reviewed by Nuechterlein and Dawson (1984); Spaulding, Garbin, and Dras (1989); Rund and Landrø (1990); and Braff (1991). It has been shown that schizophrenics have vigilance deficits compared to normal controls.

Researchers have also been interested in investigating the span of apprehension of schizophrenics (reporting the items appearing in a stimulus). Rund and Landrø (1990) and Braff (1991) reviewed the studies on this task with schizophrenics and concluded that they show deficits in their span of apprehension compared to normal controls. Asarnow and MacCrimmon (1981) compared the span of apprehension of 35 schizophrenics, 20 bipolar patients, and 20 normal controls. They found that the schizophrenic group made significantly fewer correct detections of the target stimulus than did both the bipolar group and the normal control group. However, in studies conducted by Strauss, Bohannon, Stephens, and Pauker (1984) and Strauss, Prescott, Gutterman, and Tune (1987), it was found that both schizophrenic and bipolar patients had similar deficits in their span of apprehension.

In the Asarnow Continuous Performance task of the COGLAB, the subject is instructed to watch the screen for a specified target digit and to press a button when it appears, ignoring all other digits. The digits may appear one by one, or in an array of eight digits which may or may

not contain the target. In another condition, the subject is instructed to respond to a new target digit and ignore the old one. This task thus integrates both vigilance and span of apprehension (Spaulding, Garbin, & Dras, 1989).

The published performance of schizophrenic and bipolar patients as two generic categories on the above described information processing tasks is summarized in Table 1.

A complication in the research of information processing of schizophrenic and bipolar patients is that the patients are usually on medication which might affect their performance on information processing tasks. However, about 20% of schizophrenic patients do not respond to antipsychotics at all (Spaulding, 1989). The effects of neuroleptics on the information processing of schizophrenic patients have been reviewed by Spohn and Strauss (1989). They reported that although there is an association among neuroleptic treatment, clinical improvement, and normalization of sustained attention or vigilance in chronic schizophrenics, the normalization is incomplete even when remission has been attained. The span of apprehension of chronic schizophrenics is somewhat increased along with clinical improvement. The authors also reported that neuroleptic medication does not appear to affect simple reaction time or the reaction-time crossover effect in chronic, long-term hospitalized, or repeatedly hospitalized

Table 1

Comparison of Performance on Information Processing Tasks of Schizophrenic and Bipolar Patients with Normal Controls

	Performance	
Task	Schizophrenia	Bipolar Disorder
Mueller-Lyer illusion	impaired	unknown
Simple reaction time	RAD	unknown
Probed reaction time	impaired	unknown
Size estimation	impaired	unknown
WCST	impaired	impaired
Backward masking	impaired	impaired
CPT	impaired	unknown
Span of apprehension	impaired	results inconsistent

Note. RAD = redundancy-associated deficit; WCST = Wisconsin Card Sorting Test; CPT = Continuous Performance Test.

schizophrenic patients. They concluded that the overall effects of medication on the normalization of performance are very limited in scope and patients who show clinical improvements still evidence substantial residual dysfunction

in information processing. On the other hand, Cassens, Inglis, Appelbaum, and Gutheil (1990) argued that chronic administration (over 10 days) of neuroleptics appears to improve performance on the CPT, but shows no improvement or impairment of performance on other tasks involving attention and vigilance. Strauss, Lew, Coyle, and Tune (1985) found that lessened distractability in auditory tasks was associated with higher-serum neuroleptic levels in chronic schizophrenics. There are no published studies on the effects of neuroleptics and/or lithium on the information processing of bipolar patients.

The Present Study

Based on the above discussion of the information processing in schizophrenia and bipolar disorder, it can be seen that both schizophrenic and bipolar patients have deficits in some tasks, such as WCST and backward masking. Schizophrenics also show deficits in other tasks, such as Mueller-Lyer illusion, simple and probed reaction times, size estimation, and CPT, but the performance of bipolar patients on these tasks is unknown. Although medication may affect the performance of some of the information processing tasks in schizophrenics, the performance of other tasks are not (or only slightly) affected. These latter kinds of tasks are candidates for the biological markers of the disorder. It is hypothesized that a battery of information processing

tasks given to a group of schizophrenic patients and to a group of bipolar patients will result in two different patterns of scores. Thus, this battery of information processing tasks will possess discriminative power in differentiating schizophrenia and bipolar disorder, which could prove very helpful in clinical and research differential diagnosis. In addition, given the lack of research on many of the information processing tasks in bipolar disorder, the results obtained from this study will provide valuable data for further investigation. Because the COGLAB has already shown satisfactory discriminative power between schizophrenic patients and normal controls, it is an appropriate battery of tasks to be used in this study. Furthermore, no studies using a battery of information processing tasks on patients with schizophrenia or bipolar disorder in Taiwan exist. Thus, the applicability of this methodology in the Taiwan culture merits investigation.

CHAPTER II

METHOD

Subjects

Twenty six patients diagnosed with schizophrenia and 24 diagnosed with bipolar disorder were recruited from the Taipei City Psychiatric Center in Taiwan. Patients were first selected according to chart diagnosis by Dr. Hwei-Chuang Deng who reviewed the cases to confirm the diagnosis. Diagnosis was based on the DSM-III-R system, which is commonly used in Taiwan. One of the bipolar patients had a former diagnosis of schizoaffective disorder and had current psychotic features to her disorder, and was thus excluded from the statistical analysis in order to minimize the possibility of using subjects with incorrect diagnoses. Demographic data including sex, age, education, marital status, patient status (whether the patient is an inpatient, outpatient, or in day care treatment), as well as the Global Assessment of Functioning (GAF) Scale scores, were recorded. The period of time of hospitalization and the daily dosage of neuroleptics and/or lithium taken by each patient were also recorded. No subjects had mental retardation, severe motor dysfunction, or auditory or visual (including color blindness) problems. The 10 normal controls were recruited

from the staff of the Taipei City Psychiatric Center. Table 2 shows the demographic characteristics of the subjects, while Table 3 shows their patient status and GAF Scale scores. The numbers of schizophrenic patients with positive, negative, or mixed symptoms, and the numbers with paranoid versus nonparanoid schizophrenia are shown in Tables 4 and 5 respectively. It can be seen that the three groups are compatible with regard to sex, age, and education, however, they differ significantly regarding patient status and GAF Scale scores. All subjects were asked to sign consent forms before they participated in the research.

Procedure

The Abnormal Involuntary Movements Scale (AIMS) was administered to each subject to check for manual dexterity and motor function. No subjects showed any serious motor dysfunction that might have affected their testing performance.

Each subject sat in front of a computer screen. A simple vision test was administered to each subject, who was asked to look at a white card placed on the screen. There were black Arabic numerals from 0 to 9 written on it. The vision test numerals were 1/4" in size, which were the same size as the numerals appearing on the screen during the COGLAB testing. The subject was asked to read the numerals on the card as pointed to randomly by the experimenter. All

Table 2

Demographic Characteristics of Subjects

	Schizophrenia	Bipolar Disorder	Normal Controls
Sex[a]			
Male	13	11	5
Female	13	12	5
Age[b] (in no. of months)			
M	381	406	357
SD	83.1	92.6	60.4
Education[c] (in no. of years)			
M	12.4	13.2	14.0
SD	2.99	2.96	1.56
Know English[d]			
Yes	22	22	10
No	4	1	0

[a] $\chi^2(2, N = 59) = .0265, p = .987.$

[b] $F(2, 56) = 1.28, p = .287.$

[c] $F(2, 56) = 1.30, p = .279.$

[d] $\chi^2(2, N = 59) = 3.03, p = .220.$

Table 3

Patient Status and GAF Scale Scores of Subjects

	Schizophrenia	Bipolar Disorder	Normal Controls
Patient Status[a]			
Inpatient	7	4	--
Day Care Treatment	18	4	--
Outpatient	1	15	--
GAF Scale Scores[b]			
M	69.1	82.1	90.0
SD	11.4	3.93	0.0

Note. GAF Scale = Global Assessment of Functioning Scale--DSM-III-R version.

[a] $\chi^2(1, N = 49) = 21.9, p = .000$.

[b] $F(2, 56) = 30.1, p = .000$.

Table 4

Number of Schizophrenic Patients with Positive, Negative, and Mixed Symptoms

	Symptoms		
	Positive	Negative	Mixed
No. of schizophrenic patients	9	8	9

Table 5

Number of Subjects with Paranoid versus Nonparanoid Schizophrenia

	Paranoid	Nonparanoid
No. of schizophrenic patients	17	9

subjects passed the vision test. Following the vision test, the COGLAB was administered individually to all the subjects. A detailed description of the contents of the COGLAB can be found in Spaulding, Garbin, and Dras (1989), and the instructions of each task are given in the "Instructions for running COGLAB experimental version 3.2". A Chinese translation of these instructions was given verbally to the subjects. The following is a summary of the tasks in the COGLAB:

1. Mueller-Lyer illusion: The subject is to adjust the arrow figure on the screen until the two line segments appear equal. There are 3 trials. The difference in the lengths of the two line segments is recorded for each trial.

2. Combined reaction time: For each trial the subject presses a button upon appearance of a "PRESS DOWN" message on the screen. This is followed by a "GET READY" warning stimulus. The subject is to lift his/her finger from the button when the "GO" signal appears on the screen and a buzzer sounds simultaneously. The PI varies from 1 to 11 seconds. Sets of 6 isotemporal-PI trial series (PIs = 1, 3, 7, and 9 seconds respectively) are embedded in the protocol. On some selected trials either a medium or maximum distractor warning stimulus appears. The medium distractor is a border of large asterisks " ✱ " around the "GET READY" message, and the maximum distractor is a scattered colored

pattern around the message. There are 130 trials; the reaction time for each trial is recorded. The RAD, which is defined as the difference in reaction time between the average of the first trial of each isotemporal-PI sets (as well as isolated trials with the same PI) and the average of the subsequent trials of the isotemporal-PI sets, is calculated. In addition, the mean reaction times for each PI, with medium and maximum distractors respectively, are also recorded.

3. Size estimation: A geometric graphic figure is presented on the screen for 5 seconds. Then, after 5 seconds of no stimulus, the screen shows two duplicates of different size. The subject is to indicate which of the two is closer in size to the standard. The two choices, one being larger and the other smaller, are actually in equal linear proportions from the standard. There are 10 trials. The number of over- and under-estimations are recorded.

4. Wisconsin Card Sort: This computerized version of the Wisconsin Card Sorting Test (WCST) uses a scoring and decision rule scheme that lowers the potential floor effect of the WCST. The test demands that the subject discern through trial and error three sorting parameters (color, number, and shape). Feedback of "right" or "wrong" is provided for each card sorted. After five correct sorts, the relevant sorting parameter changes. The test terminates

after five parameter rules are correctly sorted, or after 128 trials (whichever occurs first). The total numbers of correct trials, perseverative errors, random errors, and categories completed are recorded.

5. Backward masking: In each trial, a pair of digits is presented for 17 milliseconds on the screen. It is followed either by no mask or a patterned mask (two X's) of equal duration with stimulus onset asynchronies (SOAs) of 33 or 50 milliseconds. There are 10 trials for each of the conditions of no mask, the short SOA mask, and long SOA mask. Each digit in the pair of the subject's response is scored separately; thus, the total number of digits apprehended in each condition is recorded.

6. Asarnow Continuous Performance: The subject is to watch the screen for a specified target digit and press a button when it appears. Target and distractor digits are presented for 128 milliseconds at the rate of one per second. In the first condition, targets and distractors are presented one digit at a time. In the second condition, an array of 8 digits is presented which may or may not contain the target digit. The third condition is the same as the second condition, except that the subject has to respond to a new target digit. There are 11 target digits in each condition. The number of hits and false alarms are recorded

in each condition, as well as perseverative errors in the third condition.

Statistical Analysis

Eight measures were obtained from the scores of the COGLAB for each subject. On Mueller-Lyer illusion, the average difference of the two line segments of each trial was calculated. On combined reaction time, the RAD of 4 consecutive trials with PI = 7 seconds, as well as the average probe-nonprobe difference (deficit) were calculated. On size estimation, the number of larger choices was used in the analysis. On Wisconsin Card Sort, the number of perseverative and random errors were used. On backward masking, the ratio of the total number of digits apprehended in the masked versus unmasked conditions was calculated. On Asarnow Continuous Performance, the total number of hits minus the total number of false alarms was calculated. The corresponding names of these discriminant variables are listed in Table 6.

Canonical discriminant analysis was conducted on these eight measures to examine the structure of the three subject groups. In addition, in order to investigate the differences of the performance of the three subject groups on each individual tasks, post hoc univariate analyses of variance were also conducted on each of the eight measures.

Table 6

Descriptions and Names of Discriminant Variables

Description	Name of Variable
Mueller-Lyer illusion	MUELYER
Combined reaction time	
RAD of 4 consecutive trials with PI=7s	RAD7S4T
average probe-nonprobe difference	ALLPROEF
Size estimation: overestimation	OVEREST
Wisconsin Card Sort	
perseverative errors	PERSEVER
random errors	RANDOMER
Backward masking	BACKMASK
Asarnow Continuous Performance	ASARNOW

CHAPTER III

RESULTS

The means and standard deviations of the eight discriminant variables of the three subject groups are shown in Table 7.

The results of the discriminant analysis for schizophrenic and bipolar patients showed that the overall percentage of cases correctly classified was 75.5% (see Table 8). The distribution of cases across the scores of the canonical discriminant function is shown diagrmmatically in Figure 4. The Wilks' Lambda of the canonical discrimninant function was $\lambda = .6451$, $p = .012$. The best discriminant variables and their respective standardized canonical discriminant function coefficients were PERSEVER (-.8435), MUELYER (.7416), ALLPROEF (.4551), and BACKMASK (-.4243).

The results of the discriminant analysis for schizophrenic and normal controls showed that the overall percentage of cases correctly classified was 83.3% (see Table 9). The Wilks' Lambda of the canonical discrimninant function was $\lambda = .5520$, $p = .023$. The best discriminant variables and their respective standardized canonical discriminant function coefficients were MUELYER (.6662), BACKMASK (.4865), and RANDOMER (-.2199).

Table 7

Means and Standard Deviations of Discriminant Variables

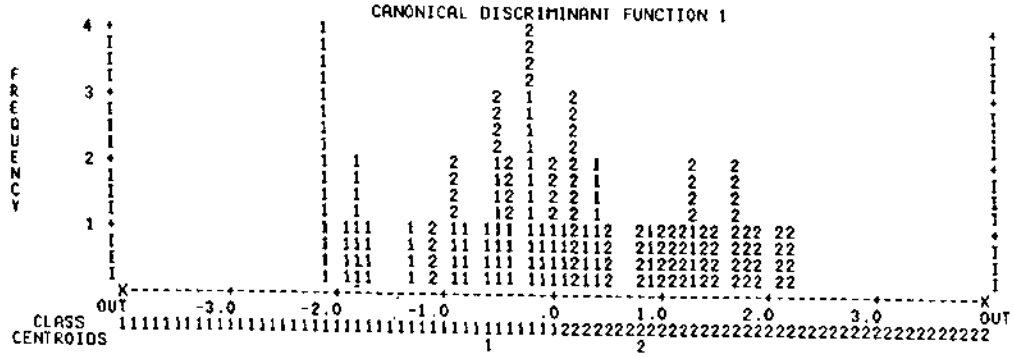
Variables		Schizophrenia	Bipolar Disorder	Normal Controls
MUELYER	M	-70.74	-60.72	-58.27
	SD	8.542	11.08	6.286
RAD7S4T	M	-1.192	13.96	5.400
	SD	37.49	32.27	27.32
ALLPROEF	M	-1.962	8.957	-.1000
	SD	40.08	22.21	17.23
OVEREST	M	3.654	4.652	4.300
	SD	2.116	2.308	2.312
PERSEVER	M	22.46	14.39	8.800
	SD	16.27	7.359	5.827
RANDOMER	M	26.69	19.57	11.00
	SD	21.18	18.39	10.85
BACKMASK	M	.5017	.5456	.8404
	SD	.2690	.2531	.1362
ASARNOW	M	22.58	24.26	26.40
	SD	7.278	6.482	4.351

Table 8

Classification Results for Schizophrenic and Bipolar Patients

		Predicted group membership	
Actual group	n	Schizophrenia	Bipolar disorder
Schizophrenia	26	20 (76.9%)	6 (23.1%)
Bipolar disorder	23	6 (26.1%)	17 (73.9%)

Note. Overall percentage of cases correctly classified: 75.5%. The best discriminant variables are PERSEVER, MUELYER, ALLPROEF, and BACKMASK.



1 Schizophrenia 2 Bipolar disorder

Figure 4. Stacked histogram of the canonical discriminant function for schizophrenic and bipolar patients.

Table 9

Classification Results for Schizophrenic Patients and Normal Controls

		Predicted group membership	
Actual group	n	Schizophrenia	Normal control
Schizophrenia	26	20 (76.9%)	6 (23.1%)
Normal control	10	0 (0%)	10 (100%)

Note. Overall percentage of cases correctly classified: 83.3%. The best discriminant variables are MUELYER, BACKMASK, and RANDOMER.

The results of the discriminant analysis for bipolar patients and normal controls showed that the overall percentage of cases correctly classified was 72.7% (see Table 10). The Wilks' Lambda of the canonical discrimninant function was $\lambda = .6392$, $p = .148$. The best discriminant variables and their respective standardized canonical discriminant function coefficients were PERSEVER (-.8165), BACKMASK (.7073), and RANDOMER (.4461).

The results of the discriminant analysis for all the three groups (schizophrenic patients, bipolar patients, and

Table 10

Classification Results for Bipolar Patients and Normal Controls

		Predicted group membership	
Actual group	n	Bipolar disorder	Normal control
Bipolar disorder	23	17 (73.9%)	6 (26.1%)
Normal control	10	3 (30%)	7 (70%)

Note. Overall percentage of cases correctly classified: 72.2%. The best discriminant variables are PERSEVER, BACKMASK, and RANDOMER.

normal controls) showed that the overall percentage of cases correctly classified was 67.8% (see Table 11). The Wilks' Lambda for both canonical discrimninant functions 1 and 2 considered simultaneously was $\lambda = .5057$, $p = .003$, and the Lambda for function 2 after function 1 had been removed was $\lambda = .8220$, $p = .173$ respectively. The best discriminant variables and their respective standardized canonical discriminant function coefficients were PERSEVER (-.7957) and MUELYER (.7312) for canonical discriminant function 1,

Table 11

Classification Results for Schizophrenic Patients, Bipolar Patients, and Normal Controls

		Predicted group membership		
Actual group	n	Schizophrenia	Bipolar disorder	Normal control
Schizophrenia	26	19 (73.1%)	4 (15.4%)	3 (11.5%)
Bipolar disorder	23	4 (17.4%)	13 (56.5%)	6 (26.1%)
Normal control	10	0 (0%)	2 (20%)	8 (80%)

Note. Overall percentage of cases correctly classified: 67.8%. The best discriminant variables are PERSEVER, MUELYER, ALLPROEF, OVEREST, and RANDOMER.

and BACKMASK (-1.0246) and ALLPROEF (.4526) for canonical discriminant function 2.

The univariate analysis of variance for schizophrenic and bipolar patients is shown in Table 12. The two groups of patients can be distinguished significantly by Mueller-Lyer

Table 12

Means and Univariate ANOVAs for Schizophrenic and Bipolar Patients

Variable	M		F	p
	Schizophrenia	Bipolar		
MUELYER	-70.74	-60.72	12.72	.0008
PERSEVER	22.46	14.39	4.785	.0337
OVEREST	3.65	4.65	2.495	.1209
RAD7S4T	-1.19	13.96	2.268	.1388
RANDOMER	26.69	19.57	1.562	.2176
ALLPROEF	-1.96	8.96	1.340	.2528
ASARNOW	22.58	24.26	.7233	.3994
BACKMASK	.50	.55	.3439	.5604

illusion and the number of perseverative errors of Wisconsin Card Sort respectively. These two variables are among the four best discriminant variables described above.

The univariate analysis of variance for schizophrenic patients and normal controls is shown in Table 13. The two groups of patients can be distinguished significantly by Mueller-Lyer illusiuon, backward masking, and both the number of perseverative errors and number of random errors

Table 13

Means and Univariate ANOVAs for Schizophrenic Patients and Normal Controls

Variable	M		F	p
	Schizophrenia	Normal		
MUELYER	-70.74	-58.27	17.53	.0002
BACKMASK	.50	.84	14.26	.0006
PERSEVER	22.46	8.80	6.621	.0146
RANDOMER	26.69	11.00	4.927	.0332
ASARNOW	22.58	26.40	2.401	.1305
OVEREST	3.65	4.30	.6408	.4290
RAD7S4T	-1.19	5.40	.2550	.6168
ALLPROEF	-1.96	-.10	.0199	.8887

of Wisconsin Card Sort respectively. These variables, except the perseverative errors, correspond to the best discriminant variables described above.

The univariate analysis of variance for bipolar patients and normal controls is shown in Table 14. The two groups can be distinguished significantly by backward masking and the number of perseverative errors of Wisconsin

Table 14

Means and Univariate ANOVAs for Bipolar Patients and Normal Controls

Variable	M		F	p
	Bipolar	Normal		
BACKMASK	.55	.84	11.91	.0016
PERSEVER	14.39	8.80	4.512	.0417
RANDOMER	19.57	11.00	1.864	.1820
ALLPROEF	8.96	-.10	1.310	.2611
ASARNOW	24.26	26.40	.9030	.3493
RAD7S4T	13.96	5.40	.5339	.4704
MUELYER	-60.72	-58.27	.4269	.5183
OVEREST	4.65	4.30	.1621	.6900

Card Sort respectively. These two variables are among the three best discriminant variables described above.

The univariate analysis of variance for all the three groups (schizophrenic patients, bipolar patients and normal controls) is shown in Table 15. The three groups can be distinguished significantly by Mueller-Lyer illusion, backward masking, and the number of perseverative errors of

Table 15

Means and Univariate ANOVAs for Schizophrenic Patients, Bipolar Patients, and Normal Controls

Variable	M			F	p
	Schizophrenia	Bipolar	Normal		
MUELYER	-70.74_a [a]	-60.72_b	-58.27_b	9.904	.0002
BACKMASK	$.50_a$	$.55_a$	$.84_b$	7.144	.0017
PERSEVER	22.46_a	14.39_b	8.80_b	5.537	.0064
RANDOMER	26.69_a	19.57_{ab}	11.00_b	2.679	.0775
ASARNOW	22.58	24.26	26.40	1.285	.2848
OVEREST	3.65	4.65	4.30	1.255	.2930
RAD7S4T	-1.19	13.96	5.40	1.212	.3053
ALLPROEF	-1.96	8.96	-.10	.8049	.4522

[a] Different letters indicate significantly different groups.

Wisconsin Card Sort respectively. These variables are among the best discriminant variables described above.

In order to understand the interrelations between the discriminant variables and thus their relative weights in the discriminant analysis, the correlation matrix (Table 16) of the eight discriminant variables for the schizophrenic and bipolar patients combined (N = 49) was calculated. The

Table 16

Correlation Matrix of Discriminant Variables for Schizophrenic and Bipolar Patients

	MUELYER	RAD7S4T	OVEREST	ALLPROEF	PERSEVER	RANDOMER	BACKMASK	ASARNOW
MUELYER	--	.3059*	.1049	.0756	-.2162	-.1660	.2822*	.0920
RAD7S4T		--	.0930	-.1799	-.3073*	-.2509	.0749	-.0135
OVEREST			--	.3868**	.0694	.0941	.0081	-.0825
ALLPROEF				--	.2817*	.1523	.0987	-.0494
PERSEVER					--	.7563**	-.3749**	-.3455*
RANDOMER						--	-.3277*	-.3327*
BACKMASK							--	.4043**
ASARNOW								--

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

Table 17

Correlation Matrix of Discriminant Variables shown separately for Schizophrenic and Bipolar Patients

	MUELYER	RAD7S4T	OVEREST	ALLPROEF	PERSEVER	RANDOMER	BACKMASK	ASARNOW
MUELYER	--	.0856	.0398	-.0354	-.1630	-.0638	.2792	-.0186
RAD7S4T	.4048	--	.1096	-.3016	-.2339	-.1455	.2439	.1154
OVEREST	-.0293	-.0277	--	.3847	.0885	.0404	.0774	.1018
ALLPROEF	.0521	-.0542	.3792	--	.4316*	.2628	.1228	.0103
PERSEVER	.0181	-.3772	.3268	.0068	--	.7918**	-.4673*	-.4472*
RANDOMER	-.1309	-.3358	.2618	.0241	.7444**	--	-.3469	-.4234*
BACKMASK	.2776	-.2022	-.1098	.0141	-.1748	-.2802	--	.5838**
ASARNOW	.0989	-.2731	-.3673	-.2654	-.0394	-.1637	.1470	--

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

Note. Above diagonal: correlations for schizophrenic patients ($N = 26$).

Below diagonal: correlations for bipolar patients ($N = 23$).

correlation coefficients of the following pairs of variables have significance levels less than .01: OVEREST-ALLPROEF, PERSEVER-RANDOMER, PERSEVER-BACKMASK, and BACKMASK-ASARNOW. The correlation coefficients of the following pairs of variables have significance levels less than .05 and greater than .01: MUELYER-RAD7S4T, MUELYER-BACKMASK, RAD7S4T-PERSEVER, ALLPROEF-PERSEVER, PERSEVER-ASARNOW, RANDOMER-BACKMASK, and RANDOMER-ASARNOW. Table 17 shows the correlation matrix of the discriminant variables for schizophrenic patients (N = 26) and that for bipolar patients (N = 23). The discriminant variables of the schizophrenia group were more significantly intercorrelated than those of the bipolar group.

CHAPTER IV

DISCUSSION

This research is the first study in Taiwan in which psychiatric patients were tested by a computerized battery of information processing tasks. Since it is not required for the subjects to know English to perform these tasks (in fact only 5 out of the 59 subjects do not know English), this study provides valuable information regarding cross-cultural/ethnic comparisons of the performance of psychiatric patients on information processing tasks.

The results of this study support the hypothesis that when the COGLAB is given to a group of schizophrenic patients and to a group of bipolar patients, two different patterns of scores emerge. Thus, this battery of information processing tasks possesses discriminative power in differentiating schizophrenia from bipolar disorder. This means that these two disorders may affect at least part of the information processing of the patients in different ways. Therefore, it might be possible to make a differential diagnosis by using information processing tasks. However, it is still not clear whether schizophrenia and bipolar disorder are two distinct disorders. It remains possible that they represent the same underlying disorder except that

the information processing deficits are of different degrees on a continuum.

In this study the COGLAB correctly classified 83.3% of the subjects who were either schizophrenics or normal controls. This is compatible with the study conducted by Spaulding, Garbin, & Crinean (1989) with a classification rate of 81%. On the other hand, the COGLAB also correctly classified 72.7% of the subjects who were either bipolar patients or normal controls. The classification rate for all the subjects of the three groups was 67.8%. However, given the small sample size (N = 59) of this study, these percentages might be considered as rough estimations. Nevertheless, these results indicate that the COGLAB might be a useful instrument in differentiating between normal controls and patients with either schizophrenia or bipolar disorder. The overall data suggested that there is a tendency for the schizophrenics to be the worst performers, the normal controls the best, and the bipolar patients falling in the middle. As there are very few studies conducted on the information processing of bipolar disorder, much more research is needed; the COGLAB might be a reasonable choice as a battery of tasks to be used.

Considering the results of this study, the comparison of the performance on information processing tasks of schizophrenic and bipolar parients with normal controls

Table 18

A Modified Comparison of Performance on Information Processing Tasks of Schizophrenic and Bipolar Patients with Normal Controls

	Performance	
Task	Schizophrenia	Bipolar Disorder
Mueller-Lyer illusion	impaired	unimpaired
Simple reaction time	no 7s RAD	no 7s RAD
Probed reaction time	unimpaired	unimpaired
Size estimation	unimpaired	unimpaired
WCST	severely impaired	moderately impaired
Backward masking	moderately impaired	moderately impaired
Asarnow Continuous Performance	unimpaired	unimpaired

Note. RAD = redundancy-associated deficit, results not compared with control group; WCST = Wisconsin Card Sorting Test.

contained in Table 1 can be modified and is shown in Table 18. For Mueller-Lyer illusion, schizophrenic patients showed impairment, while there was no significant impairment for the bipolar patients. For simple reaction time, RAD was not manifested by the schizophrenic or bipolar patients, and there was no significant difference when compared to the results of the control group. For probed reaction time, size estimation, and Asarnow Continuous Performance, both schizophrenic and bipolar patients showed no significant impairment. For Wisconsin Card Sort, the schizophrenic patients showed severe impairment and the bipolar patients showed moderate impairment. For backward masking, both groups manifested moderate impairment. It appears that both schizophrenic and bipolar patients had impairment on preattentional (backward masking) and conceptual (WCST) tasks. Although patients with schizophrenia have shown impairment in all these tasks as discussed above, the results of this study indicate that there was no significant impairment for probed reaction time, size estimation, and Asarnow Continuous Performance compared to the current sample of normal controls. This might be due to the heterogeneity of the schizophrenic group in this study which included positive, negative, and mixed sypmtoms, as well as paranoid and nonparanoid schizophrenia (see Tables 4 and 5),

as research shows that most of these impairments are strongest in process nonparanoid schizophrenic patients.

From the correlation matrix of the discriminant variables for the schizophrenic and bipolar patients (see Table 16), it can be seen that each of the eight discriminant variables correlated significantly with at least one other variable. This is illustrated in Figure 5. As the discriminative power of a discriminant function is maximized if the intercorrelations of the discriminant variables are minimized, the intercorrelations of the eight discriminant variables of this study might have negatively affected the discriminative power of the analysis. Using these eight variables, the overall percentage of cases correctly classified was 75.5%. If only two discriminant variables. MUELYER and BACKMASK, are used, the classification rate is 73.5%. On the other hand, if the discriminant variables MUELYER, BACKMASK, ALLPROEF, PERSEVER. ASARNOW, and RAD7S5T (RAD of 5 consecutive trials with PI = 7s) are used, this percentage increases to 77.6%. A post hoc stepwise discriminant analysis (limiting the steps to 8) has been conducted on all the variables obtained from the COGLAB and the corresponding percentage can be increased to 85.7% (using the variables MUELYER, RAD1S4T, MAXPROEF. PERSEVER, RAD3S5T, ALLPROM9, BMCOND1, MEDPROM3; see Table 19 for descriptions of the variables not listed in

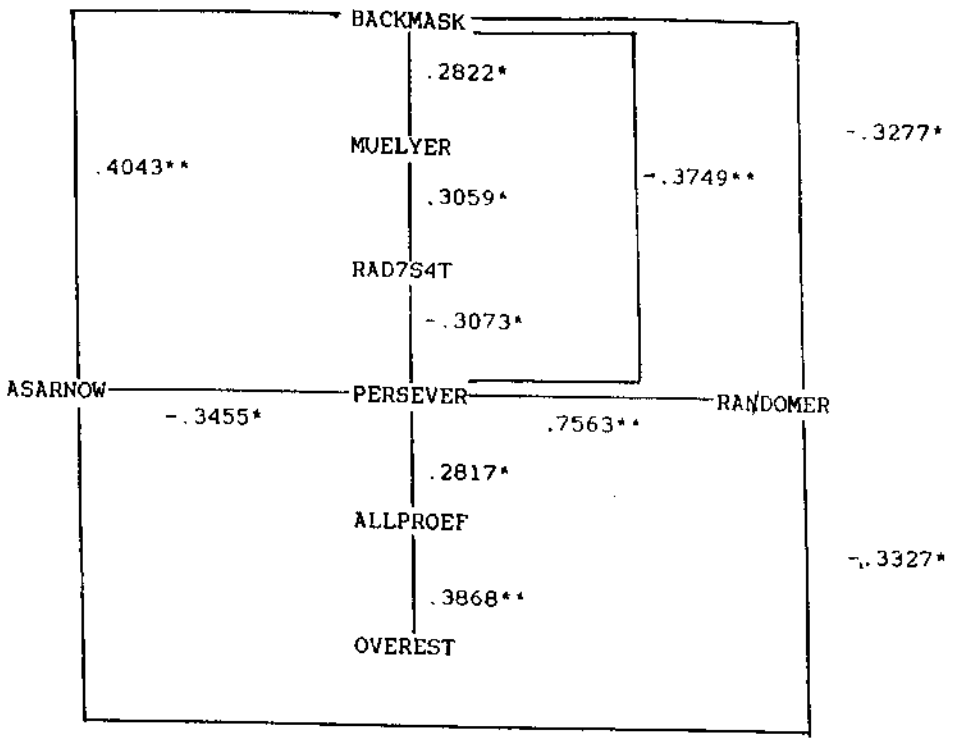


Figure 5. Significant correlations of the eight discriminant variables.

Table 6). It can be seen that the variables from size estimation and Asarnow Continuous Performance were excluded from this canonical discriminant function. This might be due to their relatively high correlations with the variables from the other tasks. On the other hand, five variables

Table 19

Descriptions and Names of other Discriminant Variables

Description	Name of Variable
Combined reaction time	
RAD of 4 consecutive trials with PI=1s	RAD1S4T
RAD of 5 consecutive trials with PI=3s	RAD3S5T
average probed effect of trials with maximum distractor	MAXPROEF
average probed effect of trials with distractors and PI=9s	ALLPROM9
averaged probed effect of trials with medium distractor and PI=3s	MEDPROM3
Backward masking	
no. of digits apprehended with no mask	BMCOND1

(RAD1S4T, MAXPROEF, RAD3S5T, ALLPROM9, and MEDPROM3) were associated with the reaction time task, which might indicate the heterogeneity of the measures obtained from this task. Further research is needed to find a rational discriminant function which is also the optimum one.

Taking the schizophrenic and bipolar patients together as a group (N = 49), the mean reaction time of the trials

with distractors and the mean reaction time of all the trials of the combined reaction time task correlated significantly with age. The former correlation was r = .3693, p = .009, and the latter correlation was r = .3377, p = .018. Thus it appears that age is a mediating factor on this task; that is, the older the subject, the slower is the reaction time. In this study, the means and standard deviations of the three groups on demographic variables including age were compatible with each other (see Table 2), and therefore the age factor is controlled substantially. However, investigators conducting research on the reaction time of human subjects should be aware of the possible intervening effects of age. On the other hand, the GAF Scale scores correlated significantly with the discriminant variables MUELYER (r = .2857, p = .047), and RAD7S4T (r = .2811, p = .05). The range of the GAF Scale scores for the schizophrenic patients of this study was from 50 to 88, and that for the bipolar patients was from 75 to 88 (there are 12 schizophrenic patients with GAF Scale scores equal or greater than 75). However, the GAF Scale scores of the three groups differed significantly (see Table 3). Thus, the discriminative power of these variables might include some artifact effects. This should be clarified with further research.

Regarding the effects of medication on the discriminant variables, the dosage of lithium of bipolar patients correlated significantly with PERSEVER (r = −.5105, p = .015). That is, the higher the dosage, the less is the number of perseverative errors on Wisconsin Card Sort. This implies that the dosage of lithium might be a mediating factor for the performance of the WCST and further research is required to investigate this mediating effect.

There are several limitations of this study. Regarding the discriminant analysis, because only a limited number of subjects were in each of the three groups, it was impossible to subdivide the schizophrenic and bipolar patients into their relevant diagnostic subtypes. For example, schizophrenic patients can be categorized under the dimensions of paranoid versus nonparanoid (Magaro, 1984a, 1984b), or positive versus negative symptoms (Walker et al., 1988). Research suggests that negative symptoms may be associated with some information processing deficits (Braff, 1989; Merriam, Kay, Weiner, & Opler, 1990; Weiner, Opler, Kay, Merriam, & Papouchis, 1990). On the other hand, Green and Walker (1986b) suggested that positive symptoms are associated with greater susceptibility to distraction. For the schizophrenic patients in this study, positive symptoms (a binomial variable) correlated significantly with the discriminant variable BACKMASK (r = −.4414, p = .024), and

paranoid schizophrenic patients appeared to have positive symptoms (r = .3908, p = .048). The possible within-group differences in the performance of the information processing tasks of this study might have affected the discriminative power of these tasks.

The significance level (p) of the Wilks' Lambda (λ) obtained in a discriminant analysis depends on the ratio of the number of subjects to the number of discriminant variables. That is, the lower this ratio, the higher is the value of p. and thus increases the probability of obtaining the canonical discriminant functions by chance. The limited number of subjects in this study, therefore, restricted the number of discriminant variables used in the discriminant analysis. Moreover, the small number of normal controls (N = 10) in this study might have led to the inability to significantly discriminate the bipolar patients and normal controls because the discriminate function obtained had insignificant .

Another limitation of this study is that both the schizophrenic and bipolar patients were on medication. As described above, neuroleptics and/or lithium might affect the information processing of these patients. However, as there are no established formulas to equate dosages of neuroleptics with dosages of lithium, these possible effects were not controlled in this study.

This study focused only on using information processing tasks to differentiate schizophrenia and bipolar disorder. It did not attempt to investigate the actual neuropsychological processes to confirm or disconfirm any proposed information processing models. By the same token, it was not intended to distinguish between state- versus trait-dependent components in the information processing of patients with mental disorders. The former is considered to be changeable while the latter unchangeable during a person's lifetime. For example, reaction-time crossover has been proposed as a trait marker of schizophrenia (Rosenbaum, Shore, & Chapin, 1988). However, the response patterns of the patient groups of this study suggest directions for future research to understand the actual information processes both psychologically and physiologically.

CHAPTER V

SUMMARY AND CONCLUSIONS

A computerized battery of information processing tasks, called the COGLAB, was administered to three subject groups: patients with schizophrenia, patients with bipolar disorder, and normal controls. Discriminant analyses were used to investigate the differences among the three groups. Results indicated that the COGLAB correctly classified 75.5% of the cases of schizophrenia and bipolar disorder. The results of univariate analyses of variance show that Mueller-Lyer illusion and the number of perseverative errors of Wisconsin Card Sort manifested significant differences between the two groups. The intercorrelations of the discriminant variables of the discriminant analysis might have negatively affected the discriminative power of the analysis. Further research is needed to fully understand the details of the information processing in schizophrenia and bipolar disorder.

At present, it is evident that when a battery of information processing tasks is administered to a group of schizophrenic patients and to a group of bipolar patients, two different patterns of scores emerge. Although both groups show deficits in some information processing tasks, such as simple reaction time, WCST, and backward masking,

their degrees of impairment vary. It also appears that the information processing of schizophrenic patients is more impaired than that of bipolar patients.

REFERENCES

American Psychiatric Association. (1994). Diagnostic and statistical manual of mental disorders (4th ed.). Washington, DC: Author.

Asarnow, R. F., & MacCrimmon, D. J. (1981). Span of apprehension deficits during the postpsychotic stages of schizophrenia. Archives of General Psychiatry, 38, 1006-1011.

Bellack, A. S., Mueser, K. T., Morrison, R. L., Tierney, A., & Podell, K. (1990). Remediation of cognitive deficits in schizophrenia. American Journal of Psychiatry, 147, 1650-1655.

Berman, K. K., Zec, R. F., & Weinberger, D. R. (1986). Physiologic dysfunction of dorsolateral prefrontal cortex in schizophrenia: II. Role of neuroleptic treatment, attention, and mental effort. Archives of General Psychiatry, 43, 126-135.

Braff, D. L. (1989). Sensory input deficits and negative symptoms in schizophrenic patients. American Journal of Psychiatry, 146, 1006-1011.

Braff, D. L. (1991). Information processing and attentional abnormalities in the schizophrenic disorders. In P. A. Magaro (Ed.), Annual review of Psychopathology: Vol. 1.

Cognitive bases of mental disorder (pp. 263-307). Newbury Park, CA: Sage Publications, Inc.

Brockington, I. F., Kendell, R. E., Wainwright, S., Hillier, V. F., & Walker, J. (1979). The distinction between the affective psychoses and schizophrenia. British Journal of Psychiatry, 135, 243-248.

Brockington, I. F., Roper, A., Copas, J., Buckley, M., Andrade, C. E., Wigg, P., Farmer, A., Kaufman, C., & Hawley, R. (1991). Schizophrenia, bipolar disorder and depression: A discriminant analysis, using 'lifetime' psychopathology ratings. British Journal of Psychiatry, 159, 485-494.

Brown, R., Colter, N., Corsellis, J. A. N., Crow, T. J., Frith, C. D., Jagoe, R., Johnstone, E. C., & Marsh, L. (1986). Postmortem evidence of structural brain changes in schizophrenia: Differences in brian weight, temporal horn area, and parahippocampal gyrus compared with affective disorder. Archives of General Psychiatry, 43, 36-42.

Callaway, E., & Naghdi, S. (1982). An information processing model for schizophrenia. Archives of General Psychiatry, 39, 339-347.

Carr, V., & Wale, J. (1986). Schizophrenia: An information processing model. Australian and New Zealand Journal of Psychiatry, 20, 136-155.

Cassens, G., Inglis, A. K., Appelbaum, P. S., & Gutheil, T. G. (1990). Neuroleptics: Effects on neuropsychological function in chronic schizophrenic patients. Schizophrenia Bulletin, 16, 477-499.

Chapman, L. J., & Chapman, J. P. (1973). Problems in the measurement of cognitive deficit. Psychological Bulletin, 79, 380-385.

Cromwell, R. L., & Spaulding, W. (1978). How schizophrenics handle information. In W. E. Fann, I. Karacan, A. D. Pokorny, & R. L. Williams (Eds.), Phenomenology and treatment of schizophrenia (pp. 127-162). New York: Spectrum Publications, Inc.

Crow, T. J. (1984). A re-evaluation of the viral hypothesis: Is psychosis the result of retroviral integration at a site close to the cerebral dominance gene? British Journal of Psychiatry, 145, 243-253.

Crow, T. J. (1986). The continuum of psychosis and its implication for the structure of the gene. British Journal of Psychiatry, 149, 419-429.

Green, M. F., Satz, P., Ganzell, S., & Vaclav, J. F. (1992). Wisconsin Card Sorting Test performance in schizophrenia: Remediation of a stubborn deficit. American Journal of Psychiatry, 149, 62-67.

Green, M., & Walker, E. (1986a). Symptom correlates of vulnerability to backward masking in schizophrenia.

American Journal of Psychiatry, 143, 181-186.

Green, M., & Walker, E. (1986b). Attentional performance in positive- and negative-symptom schizophrenia. The Journal of Nervous and Mental Disease, 174, 208-213.

Hare, E. H., & Walter, S. D. (1978). Seasonal variation in admissions of psychiatric patients and its relation to seasonal variation in their birth. Journal of Epidemiology and Community Health, 32, 47-52.

Hoff, A. L., Shukla, S., Aronson, T., Cook, B., Ollo, C., Baruch, S., Jandorf, L., & Schwartz, J. (1990). Failure to differentiate bipolar disorder from schizophrenia on measures of neuropsychological function. Schizophrenic Research, 3, 253-260.

Hsu, W. Y. (1990). [Information processing in schizophrenia: Relationships with subtypes and symptoms]. Unpublished doctoral dissertation, National Taiwan University, Taiwan.

Keller, M. B., & Baker, L. A. (1991). Bipolar disorder: Epidemiology, course, diagnosis, and treatment. Bulletin of the Menninger Clinic, 55, 172-181.

Kendell, R. E., & Brockington, I. F. (1980). The identification of disease entities and the relationship between schizophrenic and affective psychoses. British Journal of Psychiatry, 137, 324-331.

Kendell, R. E., & Gourlay, J. (1970). The clinical

distinction between the affective psychoses and schizophrenia. British Journal of Psychiatry, 117, 261-226.

Kirkpatrick, B., & Buchanan, R. W., (1990). The neural basis of the deficit syndrome of schizophrenia. The Journal of Nervous and Mental Disease, 178, 545-555.

Klerman, G. L. (1981). The spectrum of mania. Comprehensive Psychiatry, 22, 11-20.

Klerman, G. L. (1987). The classification of bipolar disorders. Psychiatric Annals, 17, 13-17.

Knight, R. A. (1984). Converging models of deficit in schizophrenia. In W. D. Spaulding & J. K. Cole (Eds.), Nebraska Symposium on Motivation, 1983: Vol. 31. Theories of schizophrenia and psychosis (pp. 93-155). Lincoln, NE: University of Nebraska Press.

Levin, S., Yurgelun-Todd, D., & Craft, S. (1989). Contributions of clinical neuropsychology to the study of schizophrenia. Journal of Abnormal Psychology, 98, 341-356.

Lyon, M., Barr, C. E., Cannon, T. D., Mednick, S. A., & Shore, D. (1989). Fetal neural development and schizophrenia. Schizophrenia Bulletin, 15, 149-151.

Magaro, P. A. (1984a). Psychosis and schizophrenia. In W. D. Spaulding & J. K. Cole (Eds.), Nebraska Symposium on Motivation, 1983: Vol. 31. Theories of schizophrenia.

Lincoln, NE: University of Nebraska Press.

Maqaro, P. A. (1984b). Schizophrenia. In S. M. Turner & M. Hersen (Eds.), Adult psychopathology and diagnosis (pp. 140-183). New York: John Wiley & Sons, Inc.

Merriam, A. E., Kay, S. R., Weiner, R. U., & Opler, L. A. (1990). Negative schizophrenic symptoms are associated with backward masking vulnerability. Schizophrenia Research, 3, 355-356.

Miller, M. B., Chapman, L. J., Chapman, J. P., & Kwapil T. R. (1993). Slowness and the preceding preparatory interval effect in schizophrenia. Journal of Abnormal Psychology. 102, 145-151.

Mirsky, A. F., & Duncan, C. C. (1986). Etiology and expression of schizophrenia: Neurobiological and psychosocial factors. Annual Review of Psychology, 37, 291-319.

Morice, R. (1990). Cognitive inflexibility and pre-frontal dysfunction in schizophrenia and mania. British Journal of Psychiatry, 157, 50-54.

Murray, R. M., O'Callaghan, E., Castle, D. J., & Lewis, S. W. (1992). A neurodevelopmental approach to the classification of schizophrenia. Schizophrenia Bulltein, 18, 319-332.

Nuechterlein, K. H., & Dawson, M. E. (1984). Information processing and attentional functioning in the

developmental course of schizophrenic disorders. Schizophrenia Bulletin, 10, 160-202.

Paulman, R. G., Devous, M. D. Sr., Gregory, R. R., Herman, J. H., Jennings, L., Bonte, F. J., Nasrallah, H. A., & Raese, J. D. (1990). Hypofrontality and cognitive impairment in schizophrenia: Dynamic single-photon tomography and neuropsychological assessment of schizophrenic brain function. Biological Psychiatry, 27, 377-399.

Pope, H. G., & Lipinski, J. F. (1978). Diagnosis in schizophrenia and manic-depressive illness: A reassessment of the specificity of `schizophrenic' symptoms in the light of current research. Archives of General Psychiatry, 35, 811-828.

Posner, M. I., & Nakagawa, A. (1989). A cognitive neuroscience perspective to control deficits in schizophrenia. European Bulletin of Cognitive Psychology, 9, 667-670.

Rosenbaum, G., Shore, D. L., & Chapin, K. (1988). Attention deficit in schizophrenia and schizotypy: Marker versus symptom variables. Journal of Abnormal Psychology, 97, 41-47.

Rund, B. R. (1993). Backward masking performance in chronic and nonchronic schizophrenics, affectively disturbed patients, and normal control subjects. Journal of

Abnormal Psychology, 102, 74-81.

Rund, B. R., & Landrø, N. I. (1990). Information processing: A new model for understanding cognitive disturbances in psychiatric patients. Acta Psychiatrica Scandinavica, 81, 305-316.

Saccuzzo, D. P., & Braff, D. L. (1981). Early information processing deficits in schizophrenia: New findings using schizophrenic subgroups and manic control subjects. Archives of General Psychiatry, 38, 175-179.

Saccuzzo, D. P., & Braff, D. L (1986). Information-processing abnormalities: Trait- and state-dependent components. Schizophrenia Bulletin, 12, 447-458.

Schuck, J. R., & Lee, R. G. (1989). Backward masking, information processing, and schizophrenia. Schizophrenia Bulletin, 15, 491-500.

Silverstone, T., & Romans-Clarkson, S. (1989). Bipolar affective disorder: Causes and prevention of relapse. British Journal of Psychiatry, 154, 321-335.

Solso, R. L. (1988). Cognitive psychology (2nd ed.). Boston, MA: Allyn and Bacon, Inc.

Spaulding, W. (1978). The relationships of some information-processing factors to severely disturbed behavior. The Journal of Nervous and Mental Disease, 166, 417-428.

Spaulding, W. (1989, March). Spontaneous and induced cognitive changes in rehabilitation of chronic

schizophrenia. Paper presented at the Kansas-Symposium in Clinical Psychology II. Lawrence, KS.

Spaulding, W., Garbin, C. P., Crinean, W. J. (1989). The logical and psychometric prerequisites for cognitive therapy of schizophrenia. British Journal of Psychiatry, 155(suppl. 5), 69-73.

Spaulding, W., Garbin, C. P., & Dras, S. R. (1989). Cognitive abnormalities in schizophrenic patients and schizotypal college students. The Journal of Nervous and Mental Disease, 177, 717-728.

Spaulding, W., Hargrove, D. S., Crinean, W. J., & Martin, T. (1981). A microcomputer-based laboratory for psychopathology research in rural settings. Behavior Research Methods and Instrumentation, 13, 616-623.

Spaulding, W., Huntzinger, R. S., LeCompte, P., & Cromwell, R. L. (1984). Clinical and etiological implications of a specific attention deficit in schizophrenia. The Journal of Nervous and Mental Disease, 172, 279-286.

Spohn, H. E., & Strauss, M. E. (1989). Relation of neuroleptic and anticholinergic medication to cognitive functions in schizophrenia. Journal of Abnormal Psychology, 98, 367-380.

Strauss, M. E., Bohannon, W. E., Kaminsky, M. J., & Kharabi, F. (1979). Simple reaction time crossover occurs in schizophrenic outpatients. Schizophrenia Bulletin, 5,

612-615.

Strauss, M. E., Bohannon, W. E., Stephens, J. H., & Pauker, N. E. (1984). Perceptual span in schizophrenia and affective disorders. The Journal of Nervous and Mental Disease, 172, 431-435.

Strauss, M. E., Lew, M. F., Coyle, J. T., & Tune, L. E. (1985). Psychopharmacologic and clinical correlates of attention in chronic schizophrenia. American Journal of Psychiatry, 142, 497-499.

Strauss, M. E., Prescott, C. A., Gutterman, D. F., & Tune, L. E. (1987). Span of apprehension deficits in schizophrenia and mania. Schizophrenia Bulletin, 13, 699-704.

Swayze II, V. W., Andreasen, N. C., Alliger, R. J., Ehrhardt, J. C., & Yuh, W. T. C. (1990). Structural brain abnormalities in bipolar affective disorder: Ventricular enlargement and focal signal hyperintensities. Archives of General Psychiatry, 47, 1054-1059.

Tam, W. -C. C., & Sewell, K. W. (1995). Seasonality of birth in schizophrenia in Taiwan. Schizophrenia Bulletin, 21, 117-127.

Tompkins, L., Goldman, R. S., & Axelrod, B. N. (1991). Modifying the Wisconsin Card Sorting Test performance of schizophrenic patients. American Journal of Psychiatry,

148. 1613.

Walker, E. F., Harvey, P., & Perlman, D. (1988). The positive/negative symptom distinction in psychoses: A replication and extension of previous findings. The Journal of Nervous and Mental Disease, 176, 359-363.

Weinberger, D. R. (1987). Implications of normal brain development for the pathogenesis of schizophrenia. Archives of General Psychiatry, 44, 660-669.

Weiner, R. U., Opler, L. A., Kay, S. R., Merriam, A. E., & Papouchis, N. (1990). Visual information processing in positive, mixed, and negative schizophrenic syndromes. The Journal of Nervous and Mental Disease, 178, 616-626.