INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

Bell & Howell Information and Learning
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA
800-521-0600

THE UNIVERSITY OF CALGARY

Memory Scanning and Hemispheric Lateralization In Individuals With Schizophrenia and Their First Degree Relatives

by

Shelley L. Lipton

A DISSERTATION

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

CALGARY, ALBERTA

AUGUST, 1999

Abstract

Memory scanning and hemispheric lateralization were investigated in individuals with schizophrenia, their first degree relatives, a psychiatric control group, and a nonpsychiatric control group. First degree relatives were grouped as schizotypal or nonschizotypal based on scores (median-split) from the Schizotypal Personality Scale. The memory scanning task employed English letters and Chinese characters as stimuli. English letters and polygons were utilized as stimuli in a dichoptic viewing task while consonant vowels (CV) and tones were used as stimuli in a dichotic listening task. The goal of the investigation was to examine memory scanning and hemispheric lateralization in individuals with schizophrenia and their first degree relatives. It was predicted that performance of schizotypal relatives would be more similar to that of their schizophrenia probands. Additionally, it was predicted that nonschizotypal relatives would perform differently in contrast to schizotypal relatives and schizophrenia probands.

Memory scanning results indicated that all groups used a self-terminating search strategy. The group of schizophrenia patients demonstrated significantly slower scanning rates for the letter stimuli. Greater homogeneity was observed among schizotypal first degree relatives and their schizophrenia probands than among nonschizotypal first degree relatives and their schizophrenia probands for half of the tasks. Since the memory scanning task was sensitive to the stabilized schizophrenia patients and revealed homogeneity among schizotypal first degree relatives and their schizophrenia probands, it is concluded that the memory scanning task unearths a probable vulnerability marker of a predisposition to schizophrenia.

Expected asymmetries were demonstrated in dichoptic viewing. Results from dichotic listening indicated that both schizotypal and nonschizotypal first degree relatives demonstrated significantly lower right ear accuracy for CV stimuli. Additionally, both relative groups demonstrated an atypical left ear advantage for CV stimuli. Greater homogeneity was observed among schizotypal first degree relatives and their schizophrenia probands than among nonschizotypal first degree relatives and their schizophrenia probands for all dichotic listening conditions. The increased homogeneity was a result of lower accuracy rates and slower RTs among schizotypal first degree relatives and their schizophrenia probands. The dichotic CV task detected (1) atypical lateralization in first degree relatives of individuals with schizophrenia; (2) greater homogeneity among first degree schizotypal relatives and their schizophrenia probands than among nonschizotypal relatives and their schizophrenia probands; and (3) normal hemispheric lateralization in stabilized schizophrenia patients. Therefore, the task detects a probable mediating vulnerability marker of a predisposition to schizophrenia.

Acknowledgments

I continue to be indebted to many people who provided support and assistance in this study. I would like to acknowledge the individuals with schizophrenia and their family members who so generously volunteered their time. The cooperation of the research staff at the Foothills Hospital was appreciated, especially with participant recruitment and providing the necessary office space.

I would like to acknowledge my supervisor, Dr. Lary Mosley for his willingness to take on the supervision and guidance of this research. I would also like express my gratitude to Dr. David Romney for his advisory support and great sense of humor. In addition, I'd like to thank a great mentor, Dr. Bryan Hiebert.

I would like to thank Jeffrey Lipton, Joyce Dickens, and Sharon Lyons for reading early drafts and giving me the benefit of their wisdom.

Finally, I would like to thank my family and friends who have stood behind me and supported me throughout all of my academic endeavors. In particular, I would like to thank my husband Jeffrey without whose love and support this project would not have been possible. I would also like to thank my mother, Joyce Dickens who has worked very hard helping me with just about everything in my life, and my father Jim Dickens and his partner Stella Coueslan who have been great cheerleaders. My appreciation also extends to my niece, Caroline Dickens for her understanding as well as her assistance and cooperation, and to my extended family and friends whose continued understanding and support has meant so much to me.

Dedication

> Love is always patient and kind; it is never jealous; love is never boastful or conceited; it is never rude or selfish; it does not take offense, and is not resentful. Love takes no pleasure in other people's sins but delights in the truth; it is always ready to excuse, to trust, to hope, and to endure whatever comes.
> 1 Corinthians 13:4-7 (Jerusalem Bible)

This work is dedicated to Joyce Beatrice Dickens, Mary Bruhart, and Laura Dickens.

My mother and grandmothers have instilled in me a life-long love of helping others, a belief in the importance of education, and the encouragement to be persistent in the pursuit of my dreams. I deeply appreciate their kindness which has nurtured me through difficult times. As I get older, I increasingly appreciate what incredible role models they are. I am proud to be their daughter and granddaughter.

Table of Contents

List of Tables

CHAPTER FOUR

List of Figures

CHAPTER FOUR

CHAPTER I

INTRODUCTION

Researchers from Kraepelin onwards have continued to be intrigued by the cognitive deficits which have long been seen as a main feature of schizophrenia. It is well known that schizophrenia runs in families but whether, and to what extent, cognitive deficits exist in first-degree relatives is unclear. Cognitive deficits in schizophrenia appear, in part, to be the result of information processing difficulties. Some explanations for the information processing deficits in individuals with schizophrenia revolve around hemispheric lateralization (Gruzelier, Seymour, Wilson, Jolley, & Hirsch, 1988). Individuals with schizophrenia tend to show an imbalance in activity between the two cerebral hemispheres which might partially account for their cognitive dysfunction. It is unclear, however, whether first-degree relatives of individuals with schizophrenia also show a similar hemispheric imbalance.

The evidence that schizophrenia patients suffer from an information processing deficit is well documented, spanning the pioneering reaction time experiments of Shakow (e.g., Huston, Shakow, & Rigg, 1937) to more recent backward masking experiments (Braff, 1981; Knight, 1992; Saccuzzo & Braff, 1981), Span of Apprehension research (Span; Asarnow, Granholm, & Sherman, 1991) and Continuous Performance research (CPT; Nuechterlein, 1991). Virtually all these studies indicate that schizophrenia patients are less efficient than others in processing information. Although the mechanism responsible for this deficit is still unknown, one early hypothesis suggested that individuals with schizophrenia are slower in processing relevant information and consequently

information is lost from the short-term memory store (Yates, 1966). Nuechterlein and Dawson (1984a) proposed that a wide range of deficits in schizophrenia can be viewed in terms of reduced availability of attentional or processing resources. Coming from a completely different perspective, Braff, Saccuzzo, and Geyer (1991) concluded that individuals with schizophrenia manifest a failure of sensory gating. The failure in sensory gating provides insight as to why patients sometimes indicate that they feel "bombarded" by sensory input and are unable to effectively filter out extraneous stimuli. A more recent hypothesis (Hemsley, 1987; Servan-Schreiber, Cohen, & Steingard, 1996) proposes that a basic failure to represent and maintain context can account for the observed deficits by schizophrenia patients on a variety of cognitive tasks.

There are two major neuropsychological hypotheses which have been put forward to account for the reduced information processing capacity in individuals with schizophrenia. The first proposes that schizophrenia patients suffer from a dysfunctional left hemisphere (Flor-Henry, 1969, 1979) which is relatively overactivated (Gur, 1979) causing information processing in the left hemisphere to be restricted to internal cues so that consciousness becomes flooded with irrelevant thoughts. Computerized tomography scans in a discordant twin study (Reveley, Reveley, & Baldy, 1987) have shown that the left hemisphere of schizophrenia patients is less dense than the right, suggesting that lowered density reflects the loss or absence of neuronal substance, offering tangible support for the dysfunctional left hemisphere hypothesis. A number of other studies using magnetic resonance imaging, cited by Crow (1990), have also demonstrated a relative reduction in mass in the left hemisphere of schizophrenia patients. Some functional neuroimaging studies have also

supported the notion of a left hemisphere that is more active in patients than in controls (Gur et al., 1995). These findings are consistent with the notion that schizophrenia is primarily a disorder of the left hemisphere.

Although the issue of laterality is important, it would be a profound oversimplification to describe schizophrenia strictly as a left hemisphere disorder. For example, a second influential hypothesis states that it is not the hemisphere itself that is impaired but the transfer of information between hemispheres (Beaumont & Dimond, 1973; David, 1993). However, results from a well-designed study by Magaro and Page (1983) failed to confirm the interhemisphere transfer deficit hypothesis. In addition, large well-controlled studies have either failed to find any lateralized differences between schizophrenia patients and controls (Flaum et al., 1995), or emphasize right hemisphere differences (Andreasen et al., 1994). At this point, the impact of atypical laterality in schizophrenia is an open question.

It is relevant and necessary for a full understanding of schizophrenia to discover and identify characteristics of their first-degree relatives which may distinguish them from first-degree relatives of other psychiatric patients and the population at large. Holzman (1987) emphasized this when he stated that "the strategy of studying first-degree relatives should be pursued as a matter of course. The study of chronically ill patients can take us only a limited way toward understanding schizophrenia. Investigators should therefore study apparently unaffected first-degree relatives" (p.68).

In a meta-analysis Romney (1990), after reviewing pertinent studies published since 1959, concluded that relatives of individuals with schizophrenia have more dysfunctions in cognitive processes than relatives of control subjects

on a variety of psychological tests. More recently, data from an extensive study by Faraone et al. (1997) supports neuropsychological impairment in relatives.

Many of the close relatives of individuals with schizophrenia, if not actually schizophrenia patients themselves, may nevertheless be diagnosed as having schizotypal personality disorder (DSM-IV, p. 641). Schizotypal personality disorder (SPD) is hypothesized to be the predisposing personality to schizophrenia. Baron, Gruen, Asnis, and Kane (1983) reported definite SPD in 16% of the relatives of schizophrenia patients. Kendler, Masterson, Ungaro, and Davis (1984) presented similar results in a study of first-degree relatives and Grove et al. (1991) reported 10%. It is noteworthy that a number of researchers have found an impairment in information processing in schizotypal individuals (e.g., Eckblad & Chapman, 1983; Keefe et al., 1997; Lenzenweger, Cornblatt, & Putnick, 1991; Steinhauer, Zubin, Condrary, Shaw, & Peters, 1991). In a series of studies, Claridge and his colleagues (Broks, 1984; Broks, Claridge, Matheson, & Hargreaves, 1984; Claridge & Broks, 1984; Rawlings & Claridge, 1984) demonstrated a relationship between schizotypal individuals from a normal population and left hemisphere dysfunction. Raine and his colleagues (Raine, Andrews, Sheard, Walder, & Manders, 1989; Raine & Manders, 1988) also found a relationship between schizotypal individuals from a normal population and hemispheric imbalance, except that their cases, in contrast to Claridge's, showed left hemisphere overactivation. Information processing deficits and hemispheric imbalance would then be expected in the relatives of schizophrenia patients. Hallett and his colleagues (Hallett & Green, 1983; Hallett, Quinn, & Hewitt, 1986) have in fact found possible defects of interhemispheric integration in the children of schizophrenia patients and Neuchterlein and Dawson (1984) also report

information processing deficits in the children of schizophrenia patients. In addition to this, Asarnow, Nuechterlein, Torquato, Subotnik, and Fogelson (1997) investigated information processing dysfunctions in the parents of children with a schizophrenia disorder and detected impairments in the parents.

Few studies have investigated hemispheric lateralization in the adult relatives of schizophrenia probands, and have failed to differentiate those relatives who are schizotypal from those who are not. Consequently, nonschizotypal relatives may not have atypical hemispheric asymmetries. In the absence of a schizotypal relative and nonschizotypal relative segregation, the question of cerebral lateralization in relatives demands further investigation.

One important area of information processing deficits has been overlooked in schizophrenia research. Many early investigators (i.e., Bleuler) believed that memory functions were intact in schizophrenia. In their defence, documenting memory deficits in schizophrenia has been difficult for several reasons. Most importantly, there are several types of memory such as semantic memory, episodic memory, and working memory (short-term memory). With respect to language, individuals with schizophrenia have an intact repertoire. It is, therefore, reasonable to deduce that an intact memory exists for knowledge or for procedural information, that is, they seem to have an intact semantic memory. Individuals with schizophrenia have no major problems recalling events established before the onset of the disease, that is, they seem to have an intact episodic memory. Thus, it seems unlikely that the majority of individuals with schizophrenia have long-term memory problems. However, some studies (using the Span of Apprehension Test) have revealed that certain short-term memory functions are impaired in some schizophrenia patients.

Short-term memory plays a pivotal role in selecting, coding, and unitizing input information for memory storage and in searching for and retrieving information stored in memory. Understanding which stage of short-term memory processing is impaired could yield information concerning specific loci of dysfunction. Sternberg (1966, 1969a) has made use of a short-term memory search paradigm to study the retrieval of information stored in short-term memory and can determine which stage is deficient in short-term memory. Investigations of memory scanning in individuals with schizophrenia are few and methodologically questionable (cf. Koh, Szoc, & Peterson, 1977; Wishner, Stein, & Peastrel, 1977). A review of the literature reveals that investigations of memory scanning in first-degree relatives of schizophrenia patients have not been conducted. In view of this, the issue of memory scanning in individuals with schizophrenia and their first-degree relatives warrants further investigation.

The aim of this research is to determine whether the information processing deficits that have been found in individuals with schizophrenia also exist, to some degree, in their first-degree relatives. Since information processing deficits in individuals with schizophrenia tend toward atypical hemispheric lateralization and deficits in short-term memory, it is therefore appropriate to examine hemispheric lateralization and memory scanning in the first-degree relatives of schizophrenia probands.

The findings of this research will help establish whether first-degree schizotypal relatives of individuals with schizophrenia manifest the same atypical lateralization and deficits in memory scanning reported for the schizophrenia individuals. Such findings, aside from underscoring the familial nature of these dysfunctions, could help explain some of the clinical

psychopathology often found in the relatives of individuals with schizophrenia, i.e., disorganized thinking and perceptual aberrations.

CHAPTER II

LITERATURE REVIEW

This chapter provides a summary of the background literature relating to cognition in schizophrenia patients and their first-degree relatives with and without schizotypal personality disorder. It begins with an overview of the neurodevelopmental model, which describes the possible brain mechanisms involved in cognitive deficits for schizophrenia patients and is followed by a similar section pertaining to schizotypal individuals. The third section clarifies similarities and differences between schizophrenia and the related, but less severe, schizotypal personality disorder. Following this, the forth section provides an overview of information processing and cognitive deficits commonly found in schizophrenia patients and their family members. The next section focuses on 2 areas of cognition, memory scanning and hemispheric lateralization, and discusses the atypical performances observed in schizophrenia patients and schizotypal individuals. Finally, the chapter ends with a description of this study which explores cognitive deficits in individuals with schizophrenia and their schizotypal family members.

The Neurodevelopmental Model of Schizophrenia

The understanding of the pathogenesis of schizophrenia has changed dramatically in recent years. The most significant change in research is a shift in conceptual thinking about the underlying neurobiology of the disease. Researchers now favour the view that many cases of schizophrenia are caused by a defect in early brain development. Recent evidence linking schizophrenia to neuropathological changes in the brain and to early brain development (the neurodevelopmental model) is the subject of the next section.

During the 1980s, schizophrenia began to be viewed within a neurodevelopmental model. According to this model, schizophrenia is a long-term consequence of an early (most likely prenatal) abnormality in neural development. Although the abnormality occurs quite early in life, it lies silent, or at least fairly quiet, until an affected region of the brain matures and is called upon to function (Weinberger, 1987). At this time, the more prominent clinical symptoms of schizophrenia appear. The most convincing evidence that schizophrenia is associated with abnormal early brain development comes from epidemiological studies, neurohistological studies, archival-observation studies, and markers of abnormal neurodevelopment.

Epidemiological Studies

In 1957, the citizens of Helsinki experienced a severe type A2 influenza epidemic. It was unusual in that it was short lived and wide spread (2/3 of the population suffered). Mednick, Machon, Huttunen, and Bonett (1988) determined rates of schizophrenia in offspring who were in utero during the influenza epidemic and compared the rate to those of controls. Offspring of mothers who were exposed to the virus during the second trimester were at increased risk. Rates of first and third trimester were the same as controls. Influenza epidemics are rare, so this could not account for the vast majority of cases in schizophrenia. But this does show that a specific environmental factor occurring at a specific time in fetal development can increase risk for schizophrenia. Several studies have also shown increased risk of schizophrenia with exposure to influenza during the second trimester (Barr, Mednick, & Munck-Jorgenson, 1990; O' Callaghan, Sham, Takei, Glover, & Murray, 1991). These studies suggest that a virus may lead to disruption in neural development

in the second trimester and that this disruption is linked to the eventual development of schizophrenia. These authors suggest that one possible mechanism through which a virus could increase risk for schizophrenia would be by eliciting an antigenic response in the mother.

A different condition that occurs during pregnancy and involves maternal antibodies is the effects of Rhesus (Rh) incompatibility. Incompatibility of the RhD antigen (RhD^- mother/RhD^+ fetuus) can cause hemolytic disease and brain damage in the fetus during the second trimester of neurodevelopment when the transfer of antibodies to the fetus is occurring (Wyatt, 1996). Data from a large prenatal project in Denmark in 1959-1961 were combined with data from the national Psychiatric Registry (Hollister, Laing, & Mednick, 1996). Rates were compared for RH compatible and incompatible groups. When the offspring of RhD negative mothers were RhD positive, their rates of schizophrenia were nearly 3 times that when mother and offspring were RhD compatible.

On the last day of November 1939, the Soviet Union launched an invasion of Finland in what became known as the Winter War of 1939. Roughly, 25,000 Finnish soldiers were killed. Some of these soldiers left behind pregnant wives and some left behind wives with newborns. The offspring of these soldiers became experimental and control groups, respectively, in an informative study. The experimental group that experienced prenatal loss had significantly more cases of schizophrenia than did controls whose fathers died within the first years of life. All the cases of schizophrenia in the experimental group were from mothers who received the news during the second trimester or the last month of pregnancy. Again, evidence of a nongenetic second trimester event that contributes to the risk of schizophrenia.

Malnutrition is another intrauterine environmental event linked to increased risk for schizophrenia. In a unique follow-up analysis of Dutch birth cohorts subjected to severe starvation caused by the Nazi blockade of the Netherlands (the Dutch Hunger Winter), investigators found a clear relation between increased risk of subsequent hospitalization for schizophrenia and exposure to severe famine in early gestation. The risk was two times higher in the group exposed during the first trimester of gestation, while exposure at other developmental periods had no increased risk over unexposed controls (Susser & Lin, 1992; Susser et al., 1996).

Neurohistological Studies

Exposure to viruses or other environmental stressors during second trimester increases the risk for symptoms. The second trimester of development is the time for cell migration in which neurons move out of the proliferation zones and into the more distal locations in which they establish connections with other neurons. Evidence of abnormalities in cell migration in schizophrenia has been found. Several neurohistological studies have been conducted using the brains of schizophrenia patients. In one study, the authors examined the orientation of the pyramidal cells of the left hippocampus (Kovelman & Scheibal, 1984). In normal controls, the pyramidal cells were neatly aligned in rows. In schizophrenia patients, the cells showed considerable disarray. This finding of cell disorientation was later replicated in a larger sample of patients and was reported in both hemispheres (Conrad, Abebe, Austin, Forsythe, & Scheibel, 1991; Conrad & Scheibel, 1987).

The cytoarchitecture of the cortex has been examined with specialized staining techniques. A form of neural displacement has been observed in that

there appear to be too few cells in the superficial layers of the cortex and too many cells in the deeper layers (Arnold, Hyman, VanHoesen, & Damasio, 1991; Jacob & Beckman, 1986). The distribution of neurons appears to be displaced inwards into deep layers of the cortex. Because the cortex develops in an inside out fashion, the inward displacement of cells strongly suggests that the neurons failed to migrate as far as they should have. The displacement of cells could lead to a situation in which the neurons show aberrations in the degree of synaptic pruning resulting in non-optimal processing (Hoffman & McGlashan, 1993). In addition, increased neuronal density has been found in the cortex of schizophrenia patients, particularly in the prefrontal and occipital areas (Selemon, Rajkowska, & Goldman-Rakic, 1995). Their findings of decreased cortical thickness suggest that excessive synaptic pruning is the major deficit in the schizophrenia brain. Neurohistological studies make it possible to speculate that the neurons of patients fail to migrate normally to the outer layers of the cortex, but instead stop short in their migration at deeper cortical layers. This displacement prevents the optimal establishment of neural connections, which in turn causes a more excessive pruning process and a denser packing of neurons. The abnormalities in neural placement and neural connections have substantial implications for cognition.

The vast majority of individuals with schizophrenia have never been exposed to the influenza virus or other stressful prenatal events during the second trimester. Cell migration might be disrupted by processes that are under genetic control, or by the presence of a nongenetic event such as a virus. It is suggested that the relatively small number of cases that result from the virus may be mimicking the genetic predisposition for schizophrenia (Green, 1998).

Archival-Observation Studies

Studies using an archival-observation method strongly suggest that at least some of the premorbid deficits associated with schizophrenia originate from abnormal brain development. Walker, Savoie, and Davis (1994) used childhood home movies to reveal a higher rate of neuromotor abnormalities, primarily on the left side of the body, in preschizophrenia children when compared to their healthy siblings and normal controls. The abnormalities included choreoathetiod movement of the upper limbs. The preschizophrenia children also showed poorer motor skills. These differences were significant only in the first 2 years of life and then become less common. Walker (1994) has speculated that these motoric abnormalities are a reflection of underlying dysregulation in dopamine that is most apparent in the first 2 years before compensatory mechanisms are established. Later in life, the dopamine dysregulation may lead to the development of psychotic symptoms. In addition, the preschizophrenia child also often shows more negative emotions compared with the control sibling (Walker, Grimes, Davis, & Smith, 1993). The demonstration of links between childhood characteristics and schizophrenia outcome in adulthood has significant implications for the conceptualization of the disorder. Early signs of dysfunction in preschizophrenia children lend support to the assumption that constitutional vulnerability is present at birth and that developmental processes moderate its expression (Benes, Davidson, & Bird, 1986; Mirsky & Duncan, 1986; Weinberger, 1987).

Markers of Abnormal Neurodevelopment

Another approach supporting the neurodevelopmental theory has been to look for markers of abnormalities in neurodevelopment in adult schizophrenia

patients. These markers are usually physical characteristics that are measurable in adults and reveal abnormal neurodevelopmental processes that occurred before or shortly after birth. Such markers include atypical handedness (Clemenzt, Iacono, & Beiser, 1994; Green, Satz, Smith & Nelson, 1989a), dermatoglyphic signs (Bracha, Torrey, Gottesman, Bigelow, & Cunniff, 1992), and minor physical anomalies (Green, Satz, & Christenson 1994; Green, Satz, Gaier, Ganzell, & Kharabi, 1989b; O'Callaghan, Larkin, Kinsella, & Waddington, 1991).

Atypical handedness has been observed in schizophrenia adults. As a group, they show a shift away from right-handedness. It appears that the shift is largely due to an increase in mixed-handedness. Not only do they tend to switch hands between different tasks, but they also tend to switch hands for the same task over time (Green et al., 1989a; Satz & Green, 1999).

Ridges on the fingers are set down between weeks 14-22 of gestation, so disruptive events that occur during these weeks are likely to be reflected in a subtle alteration of the dermatoglyphics. A comparison of total ridge counts in monozygotic twin pairs discordant for schizophrenia suggested two groups of patients. One subgroup showed decreased ridge counts, indicating that they were smaller than their unaffected co-twin during the second trimester, perhaps due to reduced blood supply. However, a second subgroup had higher counts than their co-twin, suggesting that they were larger at this point of neurodevelopment, perhaps due to swelling (Bracha et al., 1992). Aside from total ridge counts, dermatoglyphic asymmetry has been observed and is considered a sign of disturbance in fetal neurodevelopment (Markow & Gottesman, 1989; Markow & Wandler, 1986; Mellor, 1992).

Minor physical anomalies (MPAs) are minor abnormalities of the head, feet, hands, and face. There are two reasons to expect that MPAs reflect the development of the central nervous system (CNS). First, MPAs and the CNS both derive from the ectodermal layer. Second, high rates of MPAs are associated with disorders that have known prenatal CNS involvement, such as Down's syndrome (Krouse & Kauffman, 1982). Although the specific timing of the MPAs is not well known, they likely reflect processes in the second trimester of neurodevelopment (Green, Bracha, Satz, & Christenson, 1994), a time frame that fits well with the epidemiological and histological studies.

All studies that have compared MPAs in schizophrenia patients and normal controls have found an excess of MPAs in schizophrenia patients (Green et al., 1989b). MPAs do not occur with such frequency in other psychotic disorders, suggesting some degree of specificity to schizophrenia among the psychotic disorders. In addition, the siblings of the schizophrenia patients do not appear to have an increase in MPAs, suggesting that the neural events reflected by the MPAs may be nongenetic in nature.

Recent studies appear to support the notion that markers such as MPAs, dermatoglyphics, and handedness might reflect largely nongenetic events. In a study of monozygotic twins discordant for schizophrenia, the affected twin had more subtle upper limb dysmorphology, including abnormal dermatoglyphics patterns (Bracha, Torrey, Bigelow, Lohr, & Linington, 1991). Genetic factors are obviously unable to account for differences in genetically identical twin pairs. Additional support for nongenetic factors comes from the observation that twins discordant for schizophrenia had larger intrapair differences in dermatological ridge counts compared with normal controls (Bracha et al., 1992). Also germane

to this issue is the finding that siblings of schizophrenia patients had MPA scores that were significantly lower than those of patients and comparable to those of normal controls (Green et al., 1994).

Some evidence suggests that handedness is not part of the genetic predisposition to schizophrenia (cf. Satz & Green, 1999). For example, first-degree relatives of schizophrenia patients did not demonstrate a shift in their handedness distribution (Clementz et al., 1994). Moreover, another study reported a trend for mixed-handedness to be associated with a negative family history of schizophrenia (Cannon et al., 1995).

The etiology of neurodevelopmental defects in schizophrenia is unknown, and it is reasonable to assume that several factors both genetic and nongenetic play a part. One possibility is that there are two pathways to schizophrenia, one genetic (familial) and one neurodevelopmental (sporadic) (Lewis, Reveley, Reveley, Chitkara, & Murray, 1987; Murray, Lewis, & Reveley, 1985). Neurodevelopmental abnormalities can be viewed as etiologically relevant for a primary nongenetic form of schizophrenia. In this model, some patients with schizophrenia have the genetic form of the disorder, but other patients have a phenocopy in which they have the same clinical presentation, but lack the genetic predisposition.

An alternative model is the general vulnerability/stress model of schizophrenia (Mirsky & Duncan, 1986; Zubin & Spring, 1977). According to this model, neurodevelopmental factors would be considered nongenetic stressors (challenges to a developing fetus) that interact with a genetic predisposition. In essence, these individuals are carrying a double burden of genetic vulnerability and early neurodevelopmental insult.

It is important to understand how the putative defect in early brain development affects brain function, how it varies in its clinical manifestation after birth, and why it is not manifest as schizophrenia until years later. Weinberger (1987; 1995) has speculated that neural disruption remains silent until that region of the brain is called "on line". For example, there is evidence of cellular disruption in the prefrontal cortex of schizophrenia patients. This area is not fully myelinated (and therefore not fully mature) until late adolescence. Perhaps a disruption in cell migration occurs in the second trimester, but the effects of the problem are not completely appreciated until the prefrontal cortex is called on to perform cognitive operations some two decades later. Alternatively, the delay in onset of symptoms could involve an interaction between neurotransmitters (particularly the dopamine system) and neurohormonal indicators of stress responsivity. As part of an innovative model of schizophrenia, Walker and DiForio (1997) suggest that increases in cortisol release occurring in adolescence can have an augmenting effect on dopamine activity and lead to the onset of symptoms.

In summary, this section has reviewed the neurodevelopmental theory of schizophrenia. Within this model, cognitive deficits would be expected because of the neural abnormalities and precursor behavior has been observed at very early ages. The following brief section will describe the neurodevelopmental model as it relates to schizotypal personality disorder.

Schizotypal Personality Disorder and Neural Development

Relatively little is known about the developmental course of schizotypal personality disorder (SPD). However, some data indicate that it, like schizophrenia, is preceded by subclinical motor and behavioral dysfunction in

childhood. Evidence linking SPD to neuropathological changes in the brain and to early brain development is reviewed below.

Research on the biological offspring of schizophrenia patients indicates that those who are diagnosed with SPD in adulthood showed neuromotor abnormalities in infancy (Fish, Marcus, Hans, Auerbach, & Perdue, 1992). Subjects who manifest SPD in adulthood are also characterized by greater behavioral problems in childhood, including deficits in interpersonal behavior (John, Mednick, & Schulsinger, 1982).

Furthermore, Machon, Huttunen, Mednick, and Lafosse (1995) have hypothesized that a neurodevelopmental disturbance is associated with an increased presence of SPD. They reexamined their data from the Helsinki Influenza Study (Mednick et al., 1988) and found that it is conceivable that the influenza may have increased the rate of SPD among those infected during their second trimester of gestation. They suggest that exposure to the influenza epidemic in the second trimester produces a disorganization of the brain that is expressed behaviorally as SPD symptoms.

In summary, SPD has increased neurodevelopmental disturbances, similar to those found in schizophrenia patients. However, these disturbances are not the only similarity. In order to understand how schizophrenia and SPD are similar and/or different, the next section provides background information on key dimensions of similarities and differences.

Schizophrenia and Schizotypal Personality Disorder: Similarities and Differences

It has become increasingly evident that schizophrenia encompasses a continuum of schizophrenia-like disorders from mild attenuated personality

traits resembling schizophrenia to severe, unremitting psychosis. The "milder" end of the spectrum includes individuals who manifest a schizophrenia-like schizotypal personality disorder. The precise boundaries between SPD and schizophrenia, however, have not been definitely established (Siever, Oren, Kalus, & Keefe, 1993). In addition, the extent to which schizophrenia and SPD are related genetically remains to be determined. Clarifying the similarities and differences between SPD and schizophrenia has implications for understanding the core pathophysiology of schizophrenia, as well as for shedding light on the genetic and/or environmental factors that either precipitate or protect vulnerable individuals from developing the full schizophrenia illness. The following section clarifies the similarities and differences between SPD and schizophrenia.

The history of SPD begins with the history of schizophrenia. Eugene Bleuler, in his initial description of schizophrenia illness, broadened Kraeplin's construct of dementia praecox to include what Bleuler termed latent schizophrenia (Bleuler, 1911/1950), a less severe, nonpsychotic presentation of schizophrenia. Bleuler characterized latent schizophrenia as having, in a nutshell, all the symptoms of schizophrenia but in a less severe form. He suggested that schizophrenia might be considered from a dimensional perspective and emphasized that latent schizophrenia was observed much more frequently than more severe schizophrenia.

The observation of a range of severity of symptoms in schizophrenia did not establish that similar symptoms reflected similar underlying etiologies for mild and severe cases. Empirical evidence that latent schizophrenia might share a common etiology with more severe schizophrenia was Bleuler's observation of a familial link between latent and chronic schizophrenia (Bleuler, 1911/1950).

Bleuler's contemporaries also noted a familial, nonpsychotic syndrome in the relatives of individuals with schizophrenia. Rosanoff (1911) described the relatives of patients with dementia praecox as "cranky, stubborn; worries over nothing; religious crank, nervous, queer; restless, has phobias; suspicious of friends and relatives." Kretschmer (1925) published illustrative pedigrees demonstrating the occurrence of schizophrenia-like symptoms among the family members of individuals with schizophrenia, and described in some detail the characteristics of what he called a schizoid temperament observed among some of the relatives of those patients.

The coining of the term "schizotypal" for a familial nonpsychotic schizophrenia-like syndrome was the work of Rado (1953), who abbreviated the term "schizophrenic phenotype" to "schizotype", and intended it to be the description of the observable symptoms of an individual's inherited disposition to schizophrenia before, if ever, a psychosis developed. Rado proposed that schizotypal individuals suffered from an integrative pleasure deficiency, an absence of experienced pleasure that led to a deficient motivational strength and an inability to organize purposive action. From this fundamental deficiency arose the symptoms of anhedonia, fearfulness, and disorganization, exacerbation of which led to the more severe symptoms of frank schizophrenia.

Although Rado made the initial use of the term "schizotypal", Meehl's (1962, 1989) description, theoretical rationale, and development of a program of research marked the beginning of the modern study of schizotypal disorders. Meehl proposed that an integrative neural defect, which he named "schizotaxia", is inherited by some family members of individuals with schizophrenia, and the

various forms of schizophrenia illness result from subsequent environmental influences interacting with this deficit.

The publication of the DSM-II (American Psychiatric Association, 1968) helped to further empirical work on schizophrenia-related syndromes by explicably recognizing a nonpsychotic schizophrenia-like illness as a subtype of schizophrenia. DSM-II schizophrenia, latent type, was described as having clear symptoms of schizophrenia but no history of a psychotic episode.

The evidence for a relationship between SPD and schizophrenia can be observed across a variety of domains that include phenomenology, genetics, biology, psychophysiology, and attention/cognition. Phenomenologically, for example, several characteristics of SPD patients may be viewed as milder manifestations of some of the major psychotic symptoms of acute schizophrenia psychosis. Observers of relatives of schizophrenia patients have noted certain consistent constellations of behavioral deficits including oddities of behavior, eccentricities, idiosyncratic speech, peculiar ideas, social awkwardness, and social aversion. These traits have since been refined and codified into the current DSM-IV (American Psychiatric Association, 1994) criteria for Schizotypal Personality Disorder. These criteria fall into two broad classes of behaviors- "positive" or psychotic-like symptoms and "negative" or deficit-like symptoms. SPD patients exhibit psychotic-like symptoms such as magical thinking, suspiciousness, and referential ideation, which parallel the psychotic symptoms of schizophrenia and deficit symptoms such as social isolation, poor rapport, and constricted affect, which are milder versions of the deficit symptoms of schizophrenia. These symptom clusters may represent the expression of

partially distinct underlying pathophysiological processes implicated in the schizophrenia disorders.

Clinical Features

Heterogeneity in clinical presentation is certain (Andreasen & Carpenter, 1993; Murphy, Burke, Bray, Walsh, & Kendler, 1994). The essential features of schizophrenia, according to the DSM-IV (APA, 1994) are a mixture of characteristic signs and symptoms that have been present for a significant portion of time during a 1-month period, with some signs of the disorder persisting for at least six months. Schizophrenia often begins relatively early in life and frequently leads to social, occupational, and economic impairment. The characteristic signs and symptoms are diverse, encompassing almost every aspect of cognition and behavior: perception, inferential thinking, language and communication, motor behavior, attention, volition and drive, emotion, and attention. Yet not every individual with schizophrenia manifests signs and symptoms in all these areas, nor does the clinical presentation remain stable throughout the course of illness. Manifestations of this disorder are varied, ranging from apathy, emotional remoteness, and mental impoverishment to florid delusions, hallucinations, and disordered thought.

Although there is general agreement about the definition of most symptoms, there is considerable controversy over precisely which symptoms are necessary and sufficient to reach the diagnosis of schizophrenia (cf. Flaum & Schultz, 1996). The diagnosis is made on the basis of a diverse set of characteristic signs and symptoms. Few individuals exhibit all of the characteristic symptoms, and most exhibit different symptoms at different times.

There is also no "gold standard", such as a biological test, by which to identify the illness. Hence, the diagnostic criteria must be derived by consensus.

The DSM criteria are based on several implicit assumptions about schizophrenia that have varying degrees of empirical support and are subject to ongoing debate. For example, in the DSM-III-R, primacy was given to the positive symptoms (delusions, hallucinations) rather than to negative or deficit symptoms. However, research conducted since the publication of the DSM-III-R has highlighted the importance of negative symptoms and even suggested that they demarcate a distinct subtype of the illness (Andreasen & Flaum, 1991). As investigators recognized that validity was not yet attainable in the DSM-III-R, the goal of reliability became more important in the development of the current DSM-IV thus increasing the adequacy of its diagnostic criteria (Lipton & Cancro, 1995).

With regard to schizotypal personality disorder, it is like a chronic, watered-down version of schizophrenia. According to the DSM-IV (APA, 1994) the essential features of SPD emphasize odd and peculiar ideation, which is reflected in interpersonal difficulties. The cognitive difficulties and distortions can include magical thinking, superstitious beliefs beyond those that are generally accepted in the culture, illusions, and odd appearances. An additional feature of SPD is a pervasive pattern of social deficits marked by acute discomfort with, or reduced capacity for, close relationships.

Although this criterion has good internal consistency, a primary difficulty is the significant overlap and correlation with schizoid personality disorder (Morey, 1988). In addition, it has been found that paranoid personality overlaps in clinical populations with SPD (Kass, Skodol, Charles, Spitzer, & William,

1985). Schizotypal personality disorder and paranoid personality disorder both include a criterion concerning suspiciousness, so some clinical overlap may be simply definitional. Schizotypal personality also overlaps with borderline personality disorder, with 57% of borderlines also schizotypal in one survey (Spitzer, Endicott, & Gibbon, 1979.)

Gender Differences

The literature regarding gender differences in schizophrenia is vast, as researchers try to untangle the differences. Many of the phenomenologic variables that differentiate male and female patients indicate that males are more likely to manifest more severe forms of the illness. Males have an earlier age at onset (Häfner, Hambrecht, Löffler, Munk-Jørgensen, & Riecher-Rössler, 1998), poorer premorbid adjustment (Zigler, Glick, & Marsh, 1980), more negative symptoms (Castle & Murray, 1991) and poorer response to treatment (Seeman, 1986). Similarly, all of these variables have been associated with severity of brain abnormalities, particularly ventricular enlargement. Taken together, these studies support the notion that male patients may have a more severe manifestation of the illness than female patients, which might be reflected in more structural brain abnormalities.

Assuming that early onset, more negative symptoms, poorer response to treatment and greater severity of brain abnormalities reflects more of a severe illness than is found in females, then one could expect men on average to show more impairment in neuropsychological functioning. At this point, research findings are inconsistent. For example, Goldberg, Gold, Torrey, and Weinberger (1995) compared nearly 100 neuropsychological test performances between a large sample of male and female schizophrenia patients and failed to find sex

differences. These findings are supported by a similar study by Goldstein, Seidman, Santangelo, Knapp, and Tsuang (1994). On the other hand, Lewine, Walker, Shurett, Caudle, and Haden (1996) found that male patients performed better than female patients on extensive neuropsychological tests, even though both groups performed below the norms for healthy subjects. Although the studies are inconsistent, poorer functioning among males has been suggested (Hoff, Riordan, & Delisi, 1992).

Goldstein (1991) has argued that one possible reason for the inconsistency across studies may be an artifact of sampling and/or testing methods. That is, not all men and women with schizophrenia differ. Rather, men with schizophrenia and women may be at different risk for expressing particular forms of the illness, and thus, men and women may differ in the prevalence of subtypes of schizophrenia. This has also been suggested by others who propose that men may be at higher risk for a neurodevelopmental form of schizophrenia (Castle & Murray, 1991). Therefore, in small nonrepresentative clinical samples, one may or may not sample the men and women whose subtypes differ. It is also possible that men with schizophrenia do not have more neuropsychological deficits than women with schizophrenia, but rather that neuropsychological functions may be differentially affected for men versus women depending on the timing of an insult to the brain or the timing of the expression of an abnormal gene.

In a recent study, Nopoulos, Flaum, and Andreasen (1997) confirmed the presence of a significant difference in ventricular enlargement, with male patients showing a greater volume of cerebral spinal fluid compared with healthy males, while females patients compared with healthy female subjects had

a very minimally greater ventricular volume. In addition, a pattern emerged in which the abnormalities seen in female patients were consistently more subtle than those seen in the male patients, even on those measures on which the female patients differed significantly from their comparison subjects. Nopoulos et al. (1997) concluded that with regard to brain morphology, the sex effect appears to be one of a difference in severity. Brain morphology is a difference of degree rather than pattern. That is, the brains of females with schizophrenia manifest the same patterns of abnormalities as the ones observed in males, but to a lesser degree.

With regard to schizotypal personality disorder (SPD), it appears that the condition may be slightly more common in males (APA, 1994). Most studies using self-report measures of schizotypy (e.g., SPS) report that the differences in gender mirror findings in schizophrenia: positive symptoms are more prevalent in females and males demonstrate a greater preponderance of negative symptoms (Miller & Burns, 1995; Mason, Claridge, & Williams, 1997). In contrast, Balogh, Merritt, Lennginton, and Fine (1993) did not detect any gender differences in their study. It should be noted that investigations of gender differences in schizotypal personality disorder have used participants from normal populations. Studies of gender differences with first-degree schizotypal relatives of schizophrenia probands have yet to be published.

Family and Adoption Studies

Relatives of schizophrenia probands evidence an increased morbid risk for SPD compared with relatives of controls in both adoptive and other family studies of schizophrenia patients. Conversely, an increased morbid risk for schizophrenia related disorders, as well as of chronic schizophrenia itself, has

been found in relatives of schizotypal individuals (Battaglia et al., 1991). The Danish-American adoption studies of schizophrenia (Kety, Rosenthal, Wender, & Schulsinger, 1968; Kety, Rosenthal, Wender, Schulsinger, & Jacobson, 1975; Kety, et al., 1994) are characterized by blind, controlled, empirical investigation of psychopatholgy. Starting in 1963, Kety, Rosenthal, Schulsinger, Wender, and colleagues have used a series of adoption designs to investigate the role of genetic factors in schizophrenia and other forms of psychopathology and have demonstrated that heritable genetic factors account for the observed familiality of chronic schizophrenia.

One of the original goals of this series was to elucidate which, if any, of the syndromes associated with chronic schizophrenia were observed more frequently among biological relatives of adoptees with schizophrenia than among biological relatives of control adoptees. The adoptee's family studies were designed to separate the effect of shared genetic material from that of shared family environment in the genesis of schizophrenia.

The prevalence of illness among biological relatives of adoptees with schizophrenia was compared with the prevalence among the biological relatives of well controls. The families of adoptees were studied, not the adopted children of parents with schizophrenia. This design allows for the comparison of the prevalence of illness in adoptive relatives of index and control probands in order to evaluate the effect of family environment on adoptee's illness.

Results from the Danish-American adoption studies provided empirical support for the presence of a nonpsychotic schizophrenia-like disorder, referred to as latent schizophrenia, among biological relatives of individuals with schizophrenia. Further, since the increased prevalence of latent schizophrenia

was observed among biological relatives who had not shared a family environment with the adoptee with schizophrenia, the presence of illness could be attributed to shared genes, rather than to a shared environment.

Chronic schizophrenia was observed more frequently among the biological relatives of adoptees with chronic schizophrenia (5.6%) than among the biological relatives of the control adoptees (0.9%). The nonpsychotic schizophrenia-like syndrome of latent schizophrenia was significantly concentrated among the biological relatives of the adoptees with schizophrenia (14.8%). This was more than twice the prevalence of chronic schizophrenia in those relatives. Latent schizophrenia was observed in only 0.9% of the biological relatives of controls. These results confirmed empirically Bleuler's (1911/1950) description of a more common, but less severe, schizophrenia-like illness among relatives of schizophrenia patients, and the adoption methodology used permits the conclusion that the excess of illness seen among biological relatives of schizophrenia probands was due to the influence of genes rather than family environment.

As part of the development of empirically based diagnostic criteria for the DSM-III (American Psychiatric Association, 1980), Spitzer, Endicott, and Gibbon (1979) worked toward developing an operational definition of the nonpsychotic schizophrenia-like syndrome demonstrated to be related to chronic schizophrenia in the Danish-American adoption studies. "Schizotypal personality" was chosen since the term means "like schizophrenia" (Spitzer et al., 1979). When the DSM-III criteria were blindly applied to the interviews of the Copenhagen sample from the Danish-American Study, (Kendler, Gruenberg, & Strauss, 1981), SPD was significantly concentrated among the biological relatives

of adoptees with schizophrenia, independently replicating the original findings (Kety et al., 1975) from that sample.

DSM-III-R (American Psychiatric Association, 1987) revised the diagnostic criteria for SPD by adding a criterion for odd or eccentric behavior, and by requiring five of the now nine criteria to make a diagnosis of SPD. More recently, the DSM-IV (American Psychiatric Association, 1994) retained the nine criteria of the DSM-III-R SPD with relatively minor modifications and with a reordering of the sequence of their listing. Mood disorders with psychotic features and psychotic disorders were added as exclusionary diagnosis.

Other samples and analyses have provided evidence for familial relatedness between schizophrenia and SPD. For example, Lowing, Mirsky, and Pereira (1983) applied DSM-III diagnostic criteria to the adopted away children of 39 matched pairs of parents with schizophrenia and control parents, and found SPD in 6 (15.4%) of the adopted-away children of parents with schizophrenia in comparison with 3 (7.7%) adopted-away children of control parents. Baron and colleagues' family study of schizophrenia (Baron, Gruen, Asnis, & Kane, 1983; Baron et al., 1985) found 14.6% of the first-degree relatives of chronic schizophrenia probands, a rate close to that found by previous investigators. Although the Baron and colleagues (1985) study was conducted in a nonadoptee sample and thus cannot rule out the operation of nongenetic factors in familial risk for SPD, the similarity of the rate to that found in adoptee designs suggests that nongenetic familial factors may play a relatively minor role in the observed familiality of SPD. Additionally, several other investigators have found a higher risk of schizotypal personality in the relatives of schizophrenia probands compared with the prevalence in the biological relative of controls

(Kendler & Gruenberg, 1984; Frangos, Athanassenas, Tsitourides, Katsanou, & Alexandrakou, 1985; Gershon et al., 1988; Onstad, Skre, Edvardsen, Torgersen, & Kringlen, 1991).

In addition to an increased risk of SPD in the families of individuals with schizophrenia, significantly increased risk for schizophrenia and SPD in the family members of schizotypal individuals has also been reported. Battaglia et al. (1991) observed a morbid risk for schizophrenia of 4.6% among the first-degree relatives of 21 SPD patients, compared with 1.1% and 0.6% in relatives of psychiatric and medical controls. Thaker, Adami, Moran, Lahti, and Cassady (1993) and Siever et al. (1990) have
also provided evidence for an increased morbid risk for schizophrenia related disorders as well as schizophrenia itself in relatives of schizotypal individuals.

The body of family-genetic research in schizophrenia provides considerable empirical evidence for the presence of a nonpsychotic syndrome characterized by milder forms of the symptoms of chronic schizophrenia in some of the biological relatives of individuals with schizophrenia, a syndrome described in DSM-IV as SPD. It appears then that SPD is genetically related to schizophrenia among the first-degree relatives of individuals with schizophrenia.

Genetics of Schizophrenia

There is little doubt that schizophrenia alone has a genetic component (Gottesman, 1991; Kendler & Diehl, 1993). It should be emphasized, however, that about 90% of schizophrenia patients have no parents, brothers or sisters with schizophrenia (Gottesman & Shields, 1982; McGue & Gottesman, 1989). But the probability that the monozygotic (MZ) twin of an individual with schizophrenia also suffers in some degree from schizophrenia is higher than that of a dizygotic

(DZ) twin who does not share 100% of the genetic material. It appears that schizophrenia has a genetic component although that inheritance may not follow classical Mendelian rules, with dominant and recessive genes for the major features as, for example, Huntington's chorea does.

The logic of the family study approach for schizophrenia is straight forward: if schizophrenia is an inherited disorder, relatives of schizophrenia patients should manifest a higher incidence of schizophrenia than is found in the general population. Further, for relatives of individuals with schizophrenia, the risk should increase as the number of genes they share with the patient increases. Therefore, first-degree relatives of schizophrenia patients should demonstrate a higher incidence of schizophrenia than relatives who are not closely related. Numerous studies have reported that the risk for schizophrenia in first-degree relatives of schizophrenia patients exceeds the observed rate in the general population by 10 times (Kendler & Diehl, 1993). There would appear to be little doubt then that schizophrenia manifests as a familial disorder.

When searching for information on the degree of influence exerted by hereditary and environmental factors in the etiology of schizophrenia, measures of concordance from twin studies have been used as an appropriate gauge. If genetic inheritance is a decisive influence, the MZ twins who share the same genetic material should show a far greater incidence of schizophrenia when one of them has schizophrenia than do DZ twins. (If dominant genes were involved, the incidence in the MZ twin should approach 100% whereas that in the DZ twin would be about 50%). Twin studies appear to overwhelmingly support the genetic hypothesis of schizophrenia. All of the 11 studies reviewed by Gottesman and Shields (1982) reported that individuals who have a MZ twin

with schizophrenia are over four times more likely to develop schizophrenia than individuals who have a DZ twin with schizophrenia. The logic of twin research rests upon the assumption that both MZ and DZ twins share a relatively common environment, but differ significantly in the degree to which they share genes.

While MZ twins are genetically identical, DZ twins share on the average only one-half of their genes. Therefore a higher concordance rate for schizophrenia in MZ twins than in DZ twins is most easily explained by genetic mechanisms. In support of this pattern, the pooled sample of 550 MZ and 776 DZ twin pairs reported in the review by Gottesman and Shields revealed concordance rates of 57.7% and 12.8%, respectively. Kendler's review of twin research reached similar conclusions. His summary of nine studies including 401 MZ and 478 DZ twin pairs reported concordance rates of 53% and 15% respectively. Onstad, Skre, Edvardsen, Torgersen, and Kringlen (1991) had similar findings from the Norwegian twin registry. While evidence clearly suggests a major role for genetic factors in the aggregation of schizophrenia, it is important to note the concordance rates for MZ twins do not reach 100%. That is, while genetic factors would appear substantial, they do not appear to represent the entire picture.

By far the most convincing evidence for a genetic contribution to schizophrenia is that provided by a series of adoption studies. The adoption study design removes the possibility of postnatal environmental interaction between the adopted child and biological relatives. One approach has been to study children who are adopted away from a biological parent with schizophrenia. This was the case with Heston (1966). He compared 47 adopted

children whose biological mothers had schizophrenia with a control group of 50 adopted children whose biological mothers did not have schizophrenia. The results of the study were clear: 11% of the children with biological mothers with schizophrenia developed schizophrenia; none of the children in the control group developed schizophrenia. Thus, Heston demonstrated that schizophrenia was transmitted independently of the postnatal environment created by a mother with schizophrenia. These findings were constructively replicated in the previously described Danish adoption studies of Rosenthal et al., 1968; Rosenthal, Wender, Kety, Welner, & Schulsinger, 1971). Here also the risk of schizophrenia was higher for the adopted away offspring of biological parents with schizophrenia than for the adoptees of biological parents with no known psychiatric disorder (7.7% versus 0%). The Finnish team of Tienari and colleagues (1985; 1989; 1991) also had similar results in similar adoption studies.

Although family, twin, and adoption studies have conclusively shown that genes play a role in the etiology of schizophrenia, the mechanism of genetic transmission has not been discovered. Several possibilities exist. At one extreme, it may be that a mutation in a single gene causes schizophrenia. At the other extreme, there is the possibility that many genes act in combination with one another and with the environment to cause the illness. The transmission of genes obey known biological laws, and these laws have expected mathematical descriptions. It is therefore theoretically possible to use the records of family, twin, and adoption studies to determine whether one, several, or very many genes are the cause of schizophrenia.

From the data already reviewed, it is clear that a classic Mendelian model of inheritance will not adequately explain this genetic transmission. For

example, if schizophrenia was caused by a fully penetrant dominant gene, one would expect that 50% of the offspring of one parent with schizophrenia would become an individual with schizophrenia. The observed value is much lower, about 12% (Tsuang, Winokur, & Crowe, 1980). If schizophrenia were caused by a fully penetrant recessive gene, one would expect 100% of the children with two parents with schizophrenia to be children with schizophrenia. The observed value is 36.6%. They must, however, transmit something in their genetic material, since more offspring of the unaffected become ill than would be expected if no transmission had occurred. Thus, more complex models are needed to describe the genetic transmission of schizophrenia. Quantitative or mathematical modeling studies provide a strategy for doing so.

Single major locus (SML) models propose that the pair of genes present at a single locus is responsible for the transmission. SML models accurately predict the prevalence in the general population, the prevalence in offspring of parents with schizophrenia, and the incidence in siblings of individuals with schizophrenia. However, segregation analyses that provide tests of model adequacy rule out single gene transmission (McGue & Gottesman, 1989; Risch, 1990). Those that cannot rule out the model note that the risks to MZ twins and the offspring of two parents with schizophrenia are under predicted by the SML model (Paterson, Lander, & Hewitt, 1988). The negative statistical results are compelling, but the rejection of a genetic model may merely indicate that some of the nongenetic assumptions of the model are not correct.

Several authors favor a multifactorial polygenic (MFP) model (McGue & Gottesman, 1989; Risch, 1990). This is a result of most mathematical likelihood estimates when comparing the model with the appearance of schizophrenia or

spectrum disorders in pedigrees. The MFP model assumes that several genes are responsible for schizophrenia and the additional influence of the environment results in crossing of a second threshold. The appearance of spectrum disorders is being considered as the crossing of an initial threshold. Under this model, genetic factors account for 60-70% of the familial pattern of schizophrenia. Environmental factors are important to a much lesser degree. The results cannot rule out, however, the possibility of a mixed model in which a SML component and a MFP component both exist.

A variant of the MFP model is the mixed model. The mixed model assumes that a major locus gene exists with a polygenic background and environmental factors (Prescott & Gottesman, 1993). The model takes into account the heterogeneity and the similarity of the phenotype. Carter and Chung (1980) were not able to support the mixed model but Baron (1987) found that a single recessive locus makes the largest contribution to the transmission of the liability (63%). In the model, there was also a statistical likelihood for a polygenic influence, but it was considerably lower (20%). The contribution of environmental effects (random and common sibling environment) to the variance in liability was estimated to be 17%.

An innovative approach has been suggested by Matthysse (1985) and tested in clinical samples (Matthysse, Holzman, & Lange, 1986; Holzman, Kringlen, & Matthysse, 1988). Its foundation lies in a statistical technique known as latent structure analysis. The model assumes the existence of a latent trait which is not directly observable and, depending upon its site of involvement in the brain, can cause schizophrenia or other specific phenotypic manifestations. It is hypothesized that the latent trait displays Mendelian transmission, whereas

the observable traits (e.g., schizophrenia and SPD) do not necessarily conform to such a genetic pattern.

Matthysse, Holzman, and Lange (1986) have focused primarily upon smooth pursuit eye movement (SPEM) dysfunctions as a biological marker of schizophrenia and have suggested that schizophrenia and SPEM dysfunctions may be transmitted as independent phenotypic manifestations of a single latent trait. An advantage to the additional study of SPEM dysfunctions lies in the fact that they are considerably more common in schizophrenia. SPEM dysfunctions consist of a variety of eye tracking dysfunctions including saccadic intrusions in smooth pursuit, and have been reported by these authors to occur in 51-85% of schizophrenia patients and in 45% of their biological first-degree relatives. (This contrasts to the prevalence of approximately 8% in the general population.)

Applying the latent structure model to two divergent samples, the authors concluded that SPEM dysfunctions and schizophrenia might be considered expressions of a single underlying trait that is transmitted by an autosomal dominant gene. Their results were not definitive, however, because even the latent trait model cannot account for the high risk to MZ twins and the risk to children of two parents with schizophrenia (McGue & Gottesman, 1989). Nevertheless, the work of Matthysse and colleagues (1986) indicates that the addition of neurobiological assessments to psychiatric studies of families with schizophrenia may be useful in finding genes that predispose certain individuals to developing schizophrenia.

Overall, the results from the MFP model are more promising than those from the SML model (Tsuang & Faraone, 1996). In particular, results of path analytic MFP studies support the hypothesis that schizophrenia is, to a large

extent, a disorder with a mostly genetic multifactorial etiology. Altogether, the results suggest that the MFP model deserves serious consideration. These results cannot rule out, however, the possibility of a mixed model in which a SML component and a MFP component both exist. Attempts to fit such a mixed model, however, have not been able to determine the mode of transmission (Risch & Baron, 1984; Vogler, Gottesman, McGue, & Rao, 1990). Thus, no clear decision can be made about which mode of transmission is most likely, although SML models can probably be rejected (McGue & Gottesman, 1989; Tsuang, Gilbertson, & Faraone, 1991).

The most recent area to emerge in psychiatric genetics is that of linkage studies and molecular genetics. Two independent groups of researchers (Bassett, Jones, McGillivray, & Pantzar, 1988; Sherrington et al., 1988) claimed to have demonstrated that the inheritance of a disposition to schizophrenia can be associated with genetic material on chromosome 5. Unfortunately, other linkage studies could not replicate this linkage finding, and some clearly excluded the chromosome 5 locus as being involved in schizophrenia (Aschauer et al., 1990; Detera-Wadleigh et al., 1989; Diehl, Su, & Bray, 1991; Hallmayer et al., 1992). As increasing numbers of studies fail to find linkage to chromosome 5, it becomes more reasonable to conclude that the original positive findings may not be reliable (Tsuang et al., 1996). This now seems likely, given that the group that produced the original findings of linkage found that evidence for it diminished when they extended their original sample (Gurling, 1992).

A similar situation is seen for studies of linkage to chromosome 22. Pulver et al. (1994) reported a potential linkage to chromosome 22. The finding was not statistically significant but indicated a gene that accounted for only a small

portion of schizophrenia. Two other groups found evidence consistent with this finding (Coon et al., 1994; Polymeropoulos et al., 1994) yet a second sample reported by Pulver et al. (1994) excluded linkage to chromosome 22.

Molecular genetic techniques (e.g., restriction fragment-length polymorphism and variable number tandem repeats) have been extremely successful with other disorders such as Huntington's disease, but schizophrenia has presented a challenge. One weakness in applying molecular genetic techniques to schizophrenia stems from the reliance on a psychiatric diagnosis to define the phenotype. The problem is that diagnoses such as schizophrenia are based on phenomenology, not on biological markers. Psychiatric diagnoses can change over time as certain criteria are added or deleted from diagnostic systems. An additional problem is that a diagnosis of schizophrenia is a relatively rare event, even in the families of schizophrenia patients. Failure to establish enough pedigrees yields low statistical power for the linkage analyses. Holzman and Matthysse (1990) have argued that as long as we limit the phenotype of schizophrenia to the diagnosis of schizophrenia, linkage studies will be fighting an uphill battle. The solution, they argue, lies in reformulating the notion of a schizophrenia phenotype. It is implied that researchers have the task of uncovering the underlying psychopathological processes of schizophrenia in order to explore the hidden nature of the phenotype. Studying the underlying biology (e.g., eye tracking dysfunctions) is less subject to shifting tides of opinion and the phenotype becomes considerably more frequent in families than if it is limited to the disorder alone. The combination of markers yields a much more feasible distribution of genetic analyses. Cognitive deficits offer similar possibilities. As indicators of vulnerability to schizophrenia, they may serve as

alternative versions of a schizophrenia-related phenotype that could be used for genetic linkage studies. In addition, they could provide clues about etiological processes by directing researchers toward affected brain regions and neurochemical systems (Green, 1998).

In summary, schizophrenia and SPD are very similar genetically and clinically. However, schizotypal individuals are able to function in society whereas schizophrenia usually has a devastating path. As previous sections have outlined, neurodevelopmental abnormalities in schizophrenia and SPD most likely contribute to atypical information processing and cognitive deficits. The following section focuses on the area of information processing and cognitive deficits found in schizophrenia patients and their first-degree relatives.

Information Processing and Cognitive Deficits in Schizophrenia and First-Degree Relatives

Individuals with schizotypal personality disorder (SPD) as well as offspring of schizophrenia patients appear to have deficits in information processing which are found in schizophrenia patients. Many cognitive studies in the 1970s and the 1980s were influenced by two models of normal cognition: capacity models and stage models. Although the two models are partially overlapping, they have different emphases. With capacity models, the emphasis is on the overall processing capacity of the individual (Kahneman, 1973). Deficits in cognition can be attributed to a decrease in the overall amount of processing resources, or to inefficient allocation of resources. Certain cognitive measures (e.g., the Continuous Performance Task, a measure of vigilance) are often viewed as indicators of overall attentional capacity.

Stage models emphasize a series of processing stages in which the output of one stage is fed to subsequent stages that transform and elaborate the information. When stage models are applied to schizophrenia, the goals are usually to identify the earliest stage at which a dysfunction occurs (Saccuzzo & Braff, 1988). The assumption is that a dysfunction at an early stage will have a cascading effect that will lead to disruptions in the quality of the information at later processing stages. Certain measures of early information processing, such as memory scanning and the backward masking procedure, are often viewed within a stage model.

In a more integrative model of normal cognitive processing, Cowan (1988) combines features of the other two and has heuristic value for understanding the types of attentional dysfunction that may be present in schizophrenia (Nuechterlein, Dawson, & Green, 1994). The Cowan model has several major components, including a brief sensory store, memory components, and a central executive. The sensory store is very brief, lasting for a few hundred milliseconds and is experienced as the continuation of sensory input. Unlike many other models, there is no separate box for short-term memory. Instead, short-term memory (called activated memory) is a small portion of a long-term memory store that is activated at a given time. The focus of attention is a subset of the activated memory that is in conscious awareness. The central executive directs the process of voluntary attention by controlling which items are in the focus of attention.

The Cowan model allows for a complex set of interactions among its various components and subcomponents. We can take a particular cognitive deficit in schizophrenia and see how it is explained in terms of the model

(Nuechterlein et al., 1994). For example, observed deficits in early visual and auditory processing could be explained by sensory/perceptual abnormalities that disrupt the operations of the brief sensory store. If the brief sensory store was disrupted, there could be a failure to activate the correct stimulus code in long-term store. Deficits in selective attention could be viewed as a malfunction of the central executive's control of voluntary attention, which would interfere with selection of certain stimuli for enhanced processing. The model could also explain well-documented psychophysiological abnormalities in orienting and habituation. Some patients are slow to habituate to stimuli, whereas others show fast and excessive habituation. For patients who are slow to habituate, stimuli that would normally be ignored by the central executive capture the focus of attention and pull the central executive off its primary task. For patients with excessive habituation, the process of dishabituation (orienting) is disrupted so that stimuli fail to capture the focus of attention when they normally should.

When such models are applied to schizophrenia research, cognitive deficits that initially appear unrelated can be viewed within a single framework. This approach allows researchers to dissect the information processing chain of events that are disordered in schizophrenia. Within the framework of a cognitive model, it becomes possible to look for common links among different cognitive measures. Without such models, the long list of cognitive deficits in schizophrenia appears haphazard.

Early visual processing. The Span of Apprehension Test (Span; Asarnow, Granholm, & Sherman, 1991) is a measure of relatively early visual processing. It was originally developed by Estes and Taylor (1964) and Sperling (1960). In the Span, subjects see an array of letters that are presented very briefly

(50 ms). In the forced-choice version of the Span, subjects decide which of two letters (e.g., a "T" or an "F") was in the array. The task is made more or less difficult by the number of distractor letters that are presented. Because each array of letters is presented very briefly, the visual display disappears from the screen before subjects have completed a visual search for the letter. So, instead of scanning the screen, subjects need to scan a mental representation of the array called an icon. Hence, the Span is considered to be a measure of iconic read-out.

This visual information processing task has been shown to be sensitive to schizophrenia pathology in previous studies of schizophrenia patients and individuals at risk for schizophrenia. Initially, Neale (1969) found that acute schizophrenia patients had a smaller span of apprehension than normal subjects. In subsequent studies where actively psychotic schizophrenia patients were compared to normal controls on partial report span tasks, the actively psychotic schizophrenia patients detected significantly fewer target stimuli on the most complex conditions of the task than did the normal controls (Asarnow & Sherman, 1984; Harris, Ayers, & Leek, 1985; Stranburg, Marsh, Brown, Asarnow, & Guthrie, 1984).

Asarnow, Steffy, MacCrimmon, and Cleghorn (1977) found that impaired performance on the Span differentiated a subset of foster children at heightened risk for schizophrenia, by virtue of having a biological mother with schizophrenia, from foster children without a family history of schizophrenia and from normal control children. The high risk children showing the most impairment on this task tended to show some of the prodromal behaviors characteristic of children who develop schizophrenia as adults (Asarnow, Steffy, Cleghorn, & MacCrimmon, 1979; MacCrimmon, Cleghorn, Asarnow, & Steffy,

1980). Additionally, Asarnow, Nuechterlein, and Marder (1983) found that schizotypal subjects were characterized by poor performance on the Span.

Two studies have considered performance on the Span in groups of remitted patients (Asarnow & MacCrimmon, 1978; Asarnow & MacCrimmon, 1981) who also showed impairment on this test. Neale (1971) demonstrated some degree of prognostic specificity for the task, by showing that it could differentiate between schizophrenia patients and nonpsychotic psychiatric patients. Longitudinal studies (Asarnow, Marder, Mintz, Van Putten, & Zimmerman, 1988; Nuechterlein, Edell, Norris, & Dawson, 1986; Prescott, Strauss, & Tune, 1986) corroborated the results of these cross sectional studies by revealing that individuals with schizophrenia show persistent impaired performance on this task. Finally, even in individuals without a history of schizophrenia symptoms, the Span is associated with a presence of personality and clinical features consistent with schizotypy (Asarnow et al., 1983).

Taken collectively, the Span task is sensitive to both the schizophrenia psychotic state as well as the trait of vulnerability to a schizophrenia disorder. Moreover, impairment on this task has some degree of diagnostic specificity. It thus appears that this task may tap core cognitive deficits in schizophrenia.

Backward masking. Backward masking is a procedure used to assess the earliest components of visual processing. It is a way to test how well stimuli can be stored in the sensory buffer and how rapidly they can be moved for further processing. In a form frequently used, four letters are briefly presented. The duration of the presentation (10-50 ms) is just long enough for a subject to say if a target letter (e.g., "T") was among those presented. However, if shortly thereafter, (100 ms), four more letters are flashed onto the screen in exactly the

same position, then a normal subject is unable to retrieve anything from the icon formed by the original row of letters. The second stimulus pattern is the masking stimulus. An error implies that the subject has not had the time to decode information in the sensory buffer about the first stimulus; they are only able to report the mask. Therefore, the interval between the first and second presentation is critical. This time period is called the interstimulus interval (ISI). A very short ISI prevents full retrieval from the buffer, and the subject reports only the letters of the last presentation. Because the mask appears to work backward in time, the procedure is called backward masking.

The basic result of this well replicated procedure is that schizophrenia patients require a longer ISI than healthy subjects to be able to report the target letter in the original presentation (Braff, 1981; Knight, 1992; Saccuzzo & Braff, 1981). The exact reason for the deficit is unknown, but may be related to the process by which the icon is formed. The masking effect is believed to occur because the mask prevents the full formation of the icon of the target. This inability to form a complete icon could be either because the target icon in schizophrenia is especially susceptible to disruption, or because the mask is especially powerful (Green, Nuechterlein, & Mintz, 1994). Because the backward masking effect is determined by interactions of specific visual pathways, masking procedures can help isolate the pathways involved with the performance deficit in schizophrenia. Backward masking depends on the interactions between the transient (magnocellular) and sustained (parvocellular) visual pathways (Breitmeyer, 1984; Breitmeyer & Ganz, 1976). It has been suggested that the deficit in schizophrenia may stem from a dysfunction in

which the transient channels are overactive (Green, Nuechterlein, & Mintz 1994a; Green, Nuechterlein, & Mintz 1994b; Schwartz, Evans, Pena, & Winstead, 1994).

Backward masking procedures have rarely been applied to remitted schizophrenia patients. One study (Miller, Saccuzzo, & Braff, 1979) reported deficits in remitted patients compared with matched controls, suggesting that masking performance might be an indicator of vulnerability to schizophrenia. However, the remitted patients in this study were medicated and had poor social functioning, so the degree of remission is not clear. Green (1997) administered backward masking procedures to recent-onset patients and matched controls. The remitted patients had achieved psychotic remission and were in a period of no medication. Masking deficits were found in these remitted, unmedicated patients across the test conditions, indicating that a masking performance deficit is present after the psychotic symptoms have disappeared. Poor performance is not strictly related to individuals with schizophrenia because deficits are found among schizotypal individuals and unaffected siblings of schizophrenia patients (Braff, 1981; Green, Nuechterlein, & Breitmeyer, 1997; Merritt & Balogh, 1984; Saccuzzo & Schubert, 1981).

The findings from these cross-sectional studies strongly suggest that visual masking deficits are sensitive to both the schizophrenia psychotic state as well as states of remission. First-degree relatives and schizotypal individuals also show deficits in backward masking performance which are comparable to those of schizophrenia patients. It thus appears that this task may tap core cognitive deficits in schizophrenia.

Sustained attention. The Continuous Performance Test (CPT) is a standard measure of vigilance, or sustained attention, developed by Rosvold,

Mirsky, Sarason, Bransome, and Beck (1956) and was first applied to a study of schizophrenia patients in the United States by Orzack and Kornetsky (1966). Since then, it has become one of the most frequently used tests in schizophrenia research. The test concerns discriminating relevant target from irrelevant nontarget stimuli when the stimuli are presented sequentially rather than simultaneously. The discrimination is often simple, but is presented over an extended period to measure sustained attentional performance, vigilance, and ability to maintain concentration.

Typically, a series of letters is presented briefly in a rapid sequence, less than 100 ms. Stimuli are usually presented at a rate of one per second at durations of less than 100 ms. The subject is asked to press a button when a particular letter appears (e.g., "x"). The task may be presented at different levels of difficulty (e.g., press only if an "a" is followed by an "x", or press if a letter is repeated). The most difficult version is the presentation of degraded letters that are difficult to recognize. Using signal detection theory, the CPT yields an index of the subject's ability to press to targets (signal) and not press to nontargets (noise), an ability called sensitivity. Sensitivity across an entire test is called vigilance level, and the change in sensitivity from the beginning to the end of a test is called the vigilance decrement.

Schizophrenia patients show deficits on the CPT compared with controls (Nuechterlein, 1991). Several cross-sectional studies have considered the performance of remitted (Asarnow & MacCrimmon, 1978; Wohlberg & Kornetsky, 1973) or stabilized patients (Steinhauer et al., 1991) on the CPT. Results from these studies have been consistent: schizophrenia patients, even in clinical remission, show deficits in detecting targets from moderately difficult

versions of the CPT. The deficits are found in multiple studies that have used versions with a single target (Orzack & Kornetsky, 1966), a target sequence that imposes a slight memory load (Cornblatt, Lenzenweger, & Erlenmeyer-Kimling, 1989), or in a version of the CPT that imposes a perceptual burden by using visually degraded stimuli (Nuechterlein et al., 1992). Although the presence of a deficit on the CPT is well established, the exact nature of the deficit is not clear. For example, if patients have a problem in sustained attention, then one would expect them to show a relatively sharp drop in performance over the duration of the test (i.e., a greater vigilance decrement). However, schizophrenia patients generally do not differ from normal controls in vigilance decrement (Cornblatt et al., 1989). Instead, they differ most reliably on overall sensitivity (vigilance level). Hence, it appears that the CPT taps an ability related to schizophrenia, but the critical deficit may not be sustained attention per se.

Various versions of the CPT have been administered to children at risk for schizophrenia (Cornblatt, Lenzenweger, Dworkin, & Erlenmeyer-Kimling, 1992; Nuechterlein, 1983). Taken together, the findings suggest that children of mothers with schizophrenia showed deficits on the CPT compared with children of parents without a psychiatric disorder. Several studies have used CPT performance to compare relatives of patients to controls (Grove et al., 1991; Mirsky et al., 1992; Steinhauer et al., 1991). The studies have all found differences between first-degree relatives and controls when using versions of the CPT that were moderately difficult. Similarly, CPT deficits were highly correlated with schizophrenia subjects (Keefe et al., 1997; Lenzenweger & Cornblatt, & Putnick, 1991).

The findings from these studies strongly suggest the existence of a genuine deficit in the ability to discriminate target and nontarget stimuli (impaired sensitivity). This deficit usually involves a lower overall target hit rate and a higher false alarm rate compared to normal subjects. Additionally, the evidence so far indicates that CPT deficits are sensitive to most schizophrenia states and are also prevalent in first-degree relatives and schizotypal individuals. It thus appears that this task may help to identify and delineate the nature of information processing abnormalities that are relevant to schizophrenia.

Memory. Bleuler, whose observations were so astute when it came to attentional deficits, completely missed the presence of memory deficits. He believed that memory functions were intact in schizophrenia. Part of his problem in detecting deficits in memory could be that several forms of memory exist. For example, there are different types of memory such as semantic, episodic, and working memory.

A clearer understanding of memory deficits in schizophrenia may come from the distinction between explicit (or declarative) versus implicit (or nondeclarative) forms of learning and memory (Squire, 1992; Squire & Zola-Morgan, 1988). Explicit forms of memory, (e.g., episodic memory) include tasks that rely on conscious recollection of specific, previous events that can be articulated. Recalling a list of words or a story is an explicit memory task. In contrast, implicit forms of memory occur outside of conscious awareness (i.e., semantic memory). Procedural learning is a type of implicit learning in which subjects learn how to perform a task. They demonstrate learning through improved performance on a task over a series of trials (Squire & Zola-Morgan, 1988). The distinction between explicit and implicit (procedural) learning is of

interest because amnesic patients have severe deficits in explicit learning, but have intact implicit learning (Cohen & Squire, 1980; Corkin, 1968).

Procedural learning in schizophrenia is often measured with the Pursuit Rotor Test. In this test, the subject tries to maintain contact between the tip of a light sensitive wand and a small, lit target area that moves in a circular path at a constant speed. The critical measure is not how well someone does at the beginning of the task, it is how much better they perform with practice. Hence, motor learning can be assessed over several blocks of trials. Some, but not all, studies have reported the schizophrenia patients have normal rates of improvement (Granholm, Bartzokis, Asarnow, & Marder, 1993; Kern, Green, & Wallace, 1997), on the Pursuit Rotor Test, suggesting that procedural learning is relatively intact in schizophrenia. Thus, based on studies of semantic and episodic memory, it appears unlikely that the majority of schizophrenia patients have long-term memory problems.

Short term memory. Another form of memory that has received increased attention is short term memory. Conventional short term memory usually refers to a brief and limited storage which occurs about 1 second after the sensory information has arrived centrally and lasts perhaps half a minute to several minutes. Sensory stores are usually considered to contain unprocessed sensory information for up to 1 second (Jahnke & Nowaczyk, 1998). This is a large capacity store of unprocessed data. It is also called an icon in the visual modality or echoic memory in the auditory modality.

The conventional short term store is involved with two functions which allow individuals to make data of internal or external origin available for several seconds and allow the data to be evaluated, selected, and transformed (Cowan,

1998). The latter is an aspect of working (short term) memory. Long-term stores replace the short-term and can last a lifetime.

The short-term store contains data that are being processed. It is not a passive store. One of the functions of short-term memory processing concerns the selection of task-relevant external data (from the sensory buffer) and the selection of task-relevant data from the long term memory (Kolb & Wishaw, 1998).

Individuals with schizophrenia in general demonstrate deficits in working memory. In the test of the span of attention or capacity of working memory, words or digits are displayed on a screen or spoken from a tape recorder. The last number or word is particularly easy to remember (recency effect), presumably because it is still held in the sensory buffer (ultra-short-term memory). The first items in a series have a more prominent position than those in the middle and are also easier to remember than those in the middle (primacy effect). Under conditions of distraction, Frame and Oltmanns (1982) reported that schizophrenia patients often seem to lose hold of the position of the stimulus and show a significantly weaker primacy effect. They reported that weaker primacy effects remained evident even after a marked improvement of symptoms.

The following 2 sections will describe specific areas of information processing and cognition in schizophrenia and SPD that either have not been investigated or are in need of further investigation. This will include a section on memory scanning, followed by a section on hemispheric lateralization.

Memory Scanning

The Sternberg memory scanning task (1966, 1969a) has been used in investigations of information processing and to infer cognitive processes in short-term memory. Sternberg (1966) designed this task to study the relationship of the number of elements held in memory with reaction time. The procedure illuminates the nature of retrieval from short-term memory (a memory search). Memory scanning has been used extensively in cognitive psychology as well as in studies of individual differences in cognitive ability. It is utilized as one of the measures of cognitive ability in this study.

In the 1960s, Saul Sternberg developed a memory retrieval paradigm that ranks among the most influential (Greene, 1992) and has been used across populations (Levin, Wilson, Rose, & McEvoy, 1996; Conners, Casat, Gualtieri, & Weller, 1996; Pelosi, Haywar, & Blumhardt, 1995). In a typical Sternberg task, subjects are given a series of stimuli (letters, words, digits) referred to as the memory set. The memory set varies in size from one to six items. One can either use one memory set for a block of trials (the fixed-set procedure) or a different memory set for each trial (the varied-set procedure). Two seconds after the presentation of the memory set, subjects are shown a single stimulus called the probe. The subjects are asked to indicate by pressing buttons whether the probe is a member of the memory set. On some trials, referred to as positive trials, the probe is a member of the memory set. Negative trials are those in which the probe is not a member of the memory set. The correctness of the subject's responses, however, is not the issue. The subjects are almost always accurate, because the memory set never overloads either the capacity or the duration of working memory. Rather, the main dependent variable is the reaction time of

the subject. The size of the memory set strongly influences the latency of the subject's response, but the nature of the trial (positive or negative) does not. With each additional item added to the memory set, subjects require more time to respond and the increase is constant for each item added, about 38 ms per digit (Searleman & Herrman, 1994).

Sternberg (1969a, 1975) theorized that this paradigm permits us to identify, by inference, at least four independent stages or processes of short-term memory. Each process receives an input from the preceding stage and performs a particular transformation on it. Each stage is unaffected by the duration of earlier stages. Sternberg (1969a) suggested that total reaction time is simply the sum of the durations of the independent stages. For example, the probe must be first encoded. Next, the probe must be compared with each of the items residing in working memory. After that, a decision must be made concerning a match between the probe and the items in the memory set. Finally, an overt response must be executed.

The major findings of Sternberg's (1966, 1969a) original studies were (a) mean reaction time increases linearly with memory set size, (b) mean reaction times for both negative and positive responses increase with memory set size at the same rate, and (c) the slope of the set size/reaction time regression represents the mean comparison time. On the basis of these findings, Sternberg hypothesized that the mode of second-stage scanning is serial and exhaustive.

A serial exhaustive search is one in which all comparisons are considered. For the negative trials, the search is necessarily exhaustive, because the subjects must look at all the comparisons before they know for sure whether the probe was a member of the memory set. In addition, the subjects apparently use the

same scanning procedure for the positive trials as well. That is, the slope of the positive and negative trial functions are similar, suggesting that whatever the subjects are doing on the negative trials, they're also doing on the positive trials. That is, if the memory set is 4, 2, 5, 8, and the probe is 4, Sternberg's findings suggest that the subjects continue making all the comparisons anyway, even though a match between the probe and the memory set is encountered early in the processing (Jahnke & Nowaczyk, 1998).

The difficulty with exhaustiveness is that it strikes one as being counterintuitive and inefficient (Searleman & Herrmann, 1994). Why should scanning continue after a match has occurred? Logically, one would think that as soon as a match was found, the subject would terminate the search. For example, if a subject was asked to memorize a set of 5, 2, 9, and 6, with "2" being the probe, the match would be made after the second comparison. The subject would not have to continue the comparison process any further. However, this is not what most researchers have found (Roznowski & Smith, 1993). Instead of a self-terminating serial search that ends when a match is found, the data reveal that subjects conduct an exhaustive serial search. In response to this, Sternberg (1975) proposed that while the comparison process occurs very rapidly (faster than 1/20 second), the process to decide if a match is made may take considerably longer. Therefore, rather than to take the time to make a decision after each comparison, it may be more efficient to make a comparison first and then make only one decision after the entire memory set has been scanned.

However, not everyone is convinced that retrieval from STM is best accounted for by an exhaustive serial strategy (Ashby, Tein, & Balakrishnan, 1993). Theios, Smith, Haviland, Traupmann, and Moy (1973) suggested a model

that differed from Sternberg's (1966, 1969a) serial, exhaustive model in one way. In the Theios et al. (1973) model, the search process is carried out in a self-terminating fashion (i.e., subjects stop the process as soon as they find the positive set member). In the case of serial self-terminating search, the subjects compare the probe to the items in the memory set on a one-at-a-time (serial) basis. As soon as the positive set member is encountered, the subjects stop the comparison and answer "Yes", which is why the search is called self-terminating. If the trial is a negative one, then the subjects have to consider each of the items in the memory set before answering "No". If this were the way subjects carried out the task, then one would expect that the size of the memory set produce differential effects on reaction time. However, the nature of these effects should differ in positive and negative trials. Consider a memory set of four digits (i.e., 4, 2, 5, 8) and imagine that the subjects were given the probe 8, making this a positive trial. Under these circumstances, since the subjects would have to make all the comparisons, one would expect the reaction time to be about 525 ms, the same as it would be if the probe was not in the memory set. If the probe were 2, one would expect the subject to arrive at the "Yes" response sooner than if the trial were a negative one. If the search is self-terminating, the ordinal position of the probe in the memory set should have some influence on the reaction time of positive trials. In this case, two different slopes would be produced. The slope of the positive trial function should be less steep than the slope of the negative trial function.

Theios et al. (1973) assumed that subjects have a buffer that contains all the stimuli that are likely to occur in the experiment. Each stimulus is associated with a certain response (positive or negative), and positive and negative items

are placed in this buffer. When a probe is presented, subjects search through the buffer and keep going until they find a duplicate of the probe. Subjects then determine what response is associated with the stimulus and make that response. The items are not necessarily searched randomly. Positive items tend to be searched before the negative items (which explains why reaction times to both positive and negative items increase as a function of positive memory set size). Subjects may also order the items in the buffer on the basis of their probability, frequency, or recency, which could explain why these variables influence reaction time. Since negative items are being searched as well as positive, it is understandable that reaction times on negative trials would be influenced by properties of the probe.

In general this model is quite successful in accounting for the general findings of the Sternberg paradigm. However, there is one finding that is troublesome for the Theios et al. (1973) account. This model predicts that the fastest reaction times for different set sizes should be constant. This prediction stems from the fact that there is always a certain probability that the probe item will match the very first stimulus examined in the buffer. This probability decreases as a function of the number of items in the memory set; however, even for big sets, there is always a certain probability that the probe will be the first item found in the buffer. Therefore, if one plotted the distribution of the reaction times, the fastest that subjects ever responded on trials with a positive set size of 1 should be no faster than the fastest times with set sizes of 2, 3, 4, and so on. Sternberg (1975) noted that this prediction was false. Data from Lively (1972) and Lively and Sanford (1972) show that the fastest correct reaction time to positive and negative probes increased as a function of the memory set size. The

general conclusion to be drawn is that the time needed to scan through even one item must be a function of the number of items in the memory set. This is necessary to explain why the minimum reaction time increases as a function of set size.

Several investigators have advanced a parallel processing hypothesis as an alternative to the exhaustive scanning model (Greene, 1992). In parallel processing, the subjects could compare the probe to more than one item of the memory set simultaneously. Technically, the subjects could make the comparison between the probe and all the items in the memory set simultaneously. Townsend (1990) pointed out that a parallel model could explain Sternberg's data very well. When applying a parallel model to a retrieval task involving more than one item, there is likely to be an increase for retrieval speeds for the increase in items, with the entire retrieval process not complete until the last item has been retrieved. That is, reaction time increases as a function of set size because with more items, comparisons take more time and the search is not complete until the last item has been retrieved.

There are a number of variations on this theme of parallel processes competing for mental capacity. For example, Jones and Anderson (1987) created a model in which set size effects resulted from mental activation spreading out among all of the nodes representing positive items in memory. Glass (1984) assumed that the probe is compared with a processor representing each memory set item. The comparison of the probe with the different processors occurs in parallel, and the amount of time it takes for a processor to emit a positive or negative response depends on the number of comparisons being performed.

Sternberg (1975) criticized parallel models and the concept of making a comparison between the probe and all the items in the memory set simultaneously. If the subjects were truly doing the task this way, then variations in the size of the memory set would have no effect on reaction times. Therefore Sternberg found that the evidence contradicts this line of reasoning. According to Sternberg (1969a) the serial, exhaustive model fits the data most accurately.

Only three published studies have utilized the Sternberg paradigm to compare schizophrenia patients' performance to controls. Koh, Szoc, and Peterson (1977) compared memory scanning abilities of 16 schizophrenia patients, psychiatric controls, and 16 normal controls using the Sternberg paradigm. The three group latencies increased at approximately equal rates as the memory set size increased, but the overall response latencies of both the patient groups were profoundly slower than for normals. Positive and negative slopes did not differ in any of the groups. They concluded that the schizophrenia patients' short term memory scanning is intact, and their slowness is, therefore, to be understood in terms of some dysfunction in their stimulus encoding, response selection, and/or response execution (intercept values). Marusarz and Koh (1980) subsequently replicated the 1977 study and found similar results.

Wishner, Stein, and Peastrel (1977) investigated the loci of dysfunction in the information processing systems of schizophrenia patients. They used the Sternberg paradigm because of its conceptual clarity and extensive experimental support with normal samples. Their subjects comprised 10 nonparanoid schizophrenia patients, 10 paranoid schizophrenia patients, and 12 control

subjects with alcoholism. There were no significant differences between the schizophrenia groups which were therefore combined. Intercepts of the combined schizophrenia group were significantly slower than those of the alcoholism group. The slopes for the schizophrenia group were not significantly different from the slopes of the individuals with alcoholism. However, a significant main effect was achieved for positive and negative slopes, indicating that scanning was not serial exhaustive as one would expect. The investigators conclude that a different mode of functioning for individuals with schizophrenia in information processing does not exist. It would seem then, that their speculation is inconsistent with their data.

Hemispheric Lateralization

Over 160 years have elapsed since Dax (1836) discovered that damage to the left hemisphere produces an inability to talk but damage to the right hemisphere does not affect speech. Since then it has been generally accepted that the left hemisphere plays an important role in language (Kolb & Wishaw, 1996). One major neuropsychological hypothesis put forward to account for reduced information processing capacity in individuals with schizophrenia proposes that these individuals suffer from a dysfunctional left hemisphere (Flor-Henry, 1969, 1979). Dichotic listening and dichoptic viewing tasks have been frequently employed to determine the extent to which one hemisphere is better than the other in the processing of certain material. The tasks have been used extensively in cognitive psychology and in schizophrenia research. Dichotic listening and dichoptic viewing tasks are employed in this study to assess hemispheric lateralization in schizophrenia patients and in their first degree relatives. An

overview of asymmetric hemispheric function, as well as a review of the literature of hemispheric function in schizophrenia and SPD, follows.

Asymmetries are evident with respect to function. For example, most individuals prefer to use their right hand for eating, writing, and social interactions. This implies a specialization for manual skills in the left cerebral hemisphere (Moscovitch, 1979). Asymmetries of function can be affected by environmental factors as well as genetically determined factors, such as gender and handedness (Reite et al., 1995) and age (Billings, Harrison, & Alden, 1993). Additionally, asymmetries are transient in nature within individuals and can also change over time between individuals (Zaidel, 1985).

More importantly, speech functions are situated in the left hemisphere of approximately 99% of right handed individuals. With left handers, the function is less clearly lateralized: approximately 70% of this group have speech functions in the left hemisphere (Kimura, 1992). Because of this function, the left hemisphere is considered to be the dominant hemisphere. Speech production is a sequential process and, accordingly, another important feature of the left hemisphere is sequential data processing. That means that controlled data processing is largely a feature of the left or dominant hemisphere (Tucker, 1981).

In contrast, the right hemisphere operates more holistically and is engaged in gestalt perception (Kolb & Wishaw, 1996). Indeed, a major part of the right hemisphere's special role is the processing of spatial relations. A special feature here is face recognition. Another specialization is musical appreciation. The right or nondominant hemisphere also specializes in the mediation of some forms of emotion.

Normally, the two hemispheres communicate with each other by way of a large number of neural connections constituting the commissures and the corpus callosum. In this way, each side of the brain may know or monitor what is occurring elsewhere. The importance of this ability was demonstrated by Sperry (1982). Without the connections between the two hemispheres, (or impaired communication between the hemispheres), one side may not know what the other is doing or may have difficulty accounting for the actions of the other half of the brain (Gazzaniga, 1987).

Stimulated by these findings, psychopathology researchers have offered hypotheses linking specific patterns of hemispheric dysfunction to schizophrenia. Flor-Henry (1976, 1978, 1979) was among the first to propose that schizophrenia is related to left hemisphere impairment. His hypothesis was predicated on several lines of evidence: (a) the reported association between left hemisphere lesions and schizophrenia-like symptomatology, (b) the linguistic abnormalities commonly manifested by schizophrenia patients, and (c) the results of neuropsychological studies suggesting left hemisphere dysfunction in schizophrenia patients. Gur (1978, 1979) subsequently elaborated on Flor-Henry's notions and further hypothesized that schizophrenia patients tend to overactivate their dysfunctional left hemisphere. Alternatively, it has been proposed that faulty interhemispheric communication is related to schizophrenia (Beaumont & Dimond, 1973) and that certain schizophrenia patients may show an abnormal pattern of functional lateralization (Alpert, Rubinstein, & Kesselman, 1976).

Hypotheses of lateralized cerebral dysfunction and deficits in interhemispheric transfer in schizophrenia attracted the application of two

noninvasive techniques widely utilized in experimental neuropsychology: dichotic listening and dichoptic viewing. Such techniques offered the possibility of studying information processing. The two main dependent measures employed in dichotic listening and dichoptic viewing studies are reaction time and response accuracy.

Dichotic Listening

Dichotic stimulation has frequently been employed to determine the extent to which one hemisphere is better than the other in the processing of certain auditory material. The dichotic listening task involves the simultaneous presentation of a different stimulus to each ear, whereafter the subject is required to report what was heard. If the reports from one ear are more accurate than are reports from the other ear, then the hemisphere opposite the higher scoring ear is assumed to be more efficient at processing that type of material. Investigators employing dichotic stimulation typically report a right ear advantage (REA) for verbal material such as digits, words, and consonant-vowels (CV) syllables (Kimura, 1961) and a left ear advantage (LEA) for nonverbal material (Guerrini, Dravet, Raybaud, & Rogers, 1992; Kimura, 1964; Noffsinger, 1985).

Kimura (1967) attributed the REA to the dominance of the left hemisphere for language and to the greater size and efficiency of the contralateral pathways from ear to cortex. Strauss, Kosaka, and Wada (1985) and Sparks and Geschwind (1968) suggested that left ear disadvantage with verbal stimuli reflects the degradation of information resulting from corpus callosal transfer from the right to the left hemisphere.

These neuroanatomical interpretations are based primarily on the effects of commissurotomy. The commissurotomized patients fail to report verbal items

presented to the left ear in the dichotic paradigm despite having no difficulty on monaural presentation. The destruction of the anterior corpus callosum apparently prevents input from the left ear from reaching the left hemisphere via the indirect contralateral route that goes initially to the right hemisphere and then crosses the callosal pathways. While structural and functional asymmetries are clearly important, other variables such as memory, attention, set and other factors (i.e., stimulus parameters) contribute to dichotic performance (Walker & McGuire, 1982).

If individuals with schizophrenia suffer from left hemisphere dysfunction or have inadequate cerebral dominance for language, one would predict a diminished or absent REA or even a LEA for verbal materials. Many researchers have investigated this (e.g., Karny & Nachson, 1995; Bruder, Rabinowicz, Towey, & Brown, 1995). However, only two studies (Colbourne & Lishman, 1979; Johnson & Crockett, 1982) show schizophrenia patients to have a LEA and most studies (e.g., Karny & Nachson, 1995) showed an exaggerated REA. There is also no evidence for atypical processing of tonal stimuli as studies that tested schizophrenia patients on nonverbal dichotic tasks found a perfectly normal LEA (Colbourne & Lishman, 1979; Johnson & Crockett, 1982). In fact, with respect to non-verbal stimuli, affectively ill patients showed more consistent asymmetry disturbance than schizophrenia patients (Bruder, 1983). Thus, it appears that individuals with schizophrenia are normally lateralized for linguistic and nonverbal functions.

A general methodological drawback present in most studies is a failure to use both verbal and nonverbal stimuli. This strategy would provide converging data for correct interpretations of hemispheric relationships. The importance of

the two different task situations is borne out of a study from Wexler (1986) comparing the ability to discriminate tones and fused-rhymed words (different leading consonant, same syllable, binaural overlap). The asymmetry of discrimination of tones was evident in all groups, but on the latter task (with semantic content) asymmetry attenuated or disappeared.

A second dichotic parameter, the degree of ear asymmetry, has specific relevance to the hypotheses of interhemispheric transfer deficits. If schizophrenia patients were to have interhemispheric transfer deficits similar to those found in commissurotomy patients (Milner, Taylor, & Sperry, 1968) one would expect to see a dramatically exaggerated REA due to a low level of left ear function and relatively normal right ear function. The data for schizophrenia patients do not fit this picture although there is a trend toward a greater REA in these patients than in normals in some studies. Lishman, Toore, Colbourn, McMeekan, and Mance (1978) found the enhanced REA primarily in males, Lerner, Nachson, and Carmon (1977) and Gruzelier and Hammond (1980) found enhanced REA only in paranoid schizophrenia. Negative results were found by Fennell, Moskowitz, and Backus (1982) and Hatta, Ayetani, and Yoshizaki (1984). Although individuals with schizophrenia manifest bilateral accuracy decrements, the decrement was more significant in the left than in the right ear.

Some of the differences in findings may reflect differential memory load requirements of the tasks. For example, differences in REA were found in two studies by the same investigators who used different tasks: dichotic word recall and dichotic syllabic recognition (Colbourne & Lishman, 1979; Lishman, Toore, Colbourn, McMeekan, & Mance, 1978). Berlin and McNeil (1976) have reported that dichotic digit recall and dichotic consonant-vowel tasks can yield different

results, which they attributed to differences between tasks with respect to recall, familiarity and acoustic content. The lack of stability of dichotic data is illustrated by the variations in perceptual asymmetry in the same subject when they perform similar but not identical tasks.

Whatever the correct explanation of the reported data may be, these data do not support either the left hemisphere dysfunction or the interhemispheric transfer hypothesis. Whereas exaggerated REA is especially associated with callosal disruption (Milner et al., 1968; Berlin et al., 1976), the latter patient groups do not have decrements in right ear functioning typically seen in schizophrenia patients. Moreover, commissurotomy patients typically have no difficulty on monaural presentation that some investigators have found in schizophrenia patients.

A corollary of this research is the proposal by Nachshon (1980) and Gruzelier and Hammond (1980) that increased REA may reflect an exaggerated attentional bias in schizophrenia. Consistent with these notions is the finding that subtype (paranoid vs. nonparanoid) and clinical state (hallucinating) appear to affect dichotic performance. For example, Green, Hugdahl, and Mitchel (1994) found that nonhallucinating patients showed the normal REA for a consonant-vowel version of a dichotic listening test, which indicated a left hemisphere superiority in the processing of linguistic stimuli. In contrast the hallucinating patients showed no ear advantage. Consistent with this pattern, Wexler and Heninger (1979) and Bruder and colleagues (Bruder et al., 1995) found that greater REAs in subjects with schizophrenia were associated with recovery from psychotic symptoms when fused nonsense syllables were used as stimuli. However, Wexler (1986) later found the opposite pattern (i.e., decreased REA

with recovery) when using rhymed words as stimuli. Extending their earlier work, Wexler, Giller, and Southwick (1991) observed that positive symptoms were related to overactivation of a dysfunctional left hemisphere by right hemisphere input while negative symptoms reflect a left hemisphere deficit state. Spivak, Karny, Katz, and Radwan (1996) also found similar results using paranoid/disorganized categories. These results demonstrate not only that changes in the nature of the stimuli can have an impact on the degree of REA in schizophrenia patients but also that the dichotic listening test is sensitive to clinical state. Additionally, Seidman et al. (1993) and Carr, Wale, Dewis, and Stephan (1992) found that neuroleptic medication appears to also affect dichotic performance.

While the response latency data do not support the left hemisphere dysfunction or callosal transfer deficit hypotheses, findings from dichotic reaction time (RT) and monotic studies of sustained attention and auditory acuity tend to show right ear deficits. Studies evaluating RT to verbal stimuli showed a right ear decrement in speed of response (Gruzellier & Hammond, 1979; Kugler & Caudrey, 1983; Niwa et al., 1983). Related findings include a right ear performance decrement on a sustained attention task (Niwa et al., 1983) and decreased right ear acuity over time (Gruzelier et al., 1979).

In sum, the interpretations of dichotic listening in schizophrenia are complex. Schizophrenia patients as a whole show normal dominance, although an unusual degree of variability is present. The magnitude of the REA tends to be greater in schizophrenia patients than in controls and is apparently more associated with paranoid schizophrenia. Deficits on dichotic listening, in this

case, are bilateral. The pattern of bilateral deficit with exaggerated REA is inconsistent with either unilateral damage or hemisphere transfer hypotheses.

Dichoptic Viewing

The application of dichoptic viewing or visual half-field paradigms to the study of schizophrenia began with Beaumont and Dimond (1973). In the dichoptic viewing paradigm, it is theorized that sensory input from the right or left visual field is directed to the contralateral hemisphere via the optic tract (Kolb & Wishaw, 1996). Each hemisphere receives visual input from only the contralateral half of the visual field of each eye.

By tachistoscopically presenting visual stimuli to one visual half-field, researchers (e.g., Aharonovich, Karny, & Nachson, 1993; David & Cutting, 1993) have demonstrated that dextrals generally show a right visual field advantage (RVF) for the recognition of linguistic stimuli (i.e., letters, words) and, less consistently, a left visual field (LVF) advantage for spatial stimuli (i.e., geometric forms).

As in the dichotic listening studies, there have been two major hypotheses with respect to hemispheric anomalies in schizophrenia: (1) left hemisphere dysfunction or (2) defective interhemispheric transfer of information. The study that gave major impetus to the left hemisphere dysfunction hypothesis was reported by Gur (1978). A LVF superiority in schizophrenia patients for processing visuo-spatial (dot location) and linguistic stimuli (consonant-vowel-consonant syllables) was found. Individuals with schizophrenia performed significantly more poorly on both tests; however, they did not differ from controls on the preferred hemispheric processing of the dot location task, but did differ with respect to the linguistic task.

Gur's finding of a left hemisphere visual processing deficit in schizophrenia has rarely been replicated (Magaro & Chamrad, 1983a; Magaro & Page, 1983) with the exception of a few studies (Schneider, 1983). A recent study by Carter, Robertson, Nordahl, Chaderjian, and Oshora-Celaya (1996) provided evidence consistent with Gur's ideas by showing that auditory hallucinations in schizophrenia are correlated with attention deficits indicative of left hemisphere pathology. Beaumont and Dimond (1973) demonstrated that schizophrenia patients were worse than normals in the RVF for matching letters, but that they were also worse in the LVF than psychiatric controls for matching digits and shapes. These results could suggest a bilateral deficit. Moreover, the normal controls in Beaumont and Dimond's study (patients with renal disease, diabetes, chronic obstructive pulmonary disease) might have had subtle neurological deficits. Additionally, the investigators did not specify any of the demographic, clinical, or diagnostic characteristics of the individuals with schizophrenia or other groups making this study difficult to compare to others.

Most studies using the visual half-field technique find that schizophrenia patients show the normal left hemisphere advantage in identifying letter or word stimuli and a right hemisphere advantage for visual-spatial stimuli (Magaro & Chamrad, 1983a; Magaro & Chamrad, 1983b; Fogliani, Parisi, Fogliani-Messing, & Rapisarda, 1985). Tasks differ on significant parameters across the studies: Aharonovich, Karny and Nachson (1993) used digit-pairs; Gur (1978) used consonant-vowel-consonant combinations, whereas other investigators used randomly selected letters of the alphabet (Pic'l, Magaro, & Wade, 1979) and the length of stimulus exposure and other task parameters such as the use of

backward masking by Gur (1978) differ. This latter paradigm appears to be the most distinctive difference between the studies and demonstrates that the mask may have interfered with processing by interrupting short term memory.

In contrast to the lack of support for Gur's contention on the basis of response accuracy data, the reaction time data (as with the auditory perceptual tasks) are more supportive of a left hemisphere dysfunction hypothesis. Increase in response latencies to RVF stimuli in schizophrenia patients has been reported (Hillsburg, 1979; Connelly, Gruzelier, Kleinman, & Hirsch, 1979). Clooney and Murray (1977) were the only investigators to report completely negative results on this dimension. Magaro and collaborators suggest that left hemisphere dysfunction is not related to schizophrenia in general, but just to nonparanoid schizophrenia (Magaro & Chamrad, 1983b; Magaro & Page, 1983). There is much evidence suggesting the need to distinguish between paranoid and nonparanoid schizophrenia patients when cognitive processing styles are considered (Magaro, 1980).

Magaro and collaborators consistently demonstrated that schizophrenia patients as a group do not differ from psychiatric controls or, in some studies, from normals on the usual superiority of the left hemisphere for letter naming. However, in a series of studies, they demonstrated that there were replicable distinctions between paranoid and nonparanoid schizophrenia patients on information processing styles in interaction with visual hemifield stimulation. The nonparanoid schizophrenia patients, although they exhibit RVF-left hemisphere advantages in unilateral presentations of letters, show deficits in the RVF under bilateral presentation and on spatial tasks requiring serial processing.

On the other hand, paranoid schizophrenia patients showed a LVF deficit in face recognition when unilaterally presented.

Magaro's work illustrates the crucial distinction between the structural hemisphere lesion hypothesis and that of an information processing deficit, which can be due to cerebral dysfunction not immediately involving the left hemisphere. If nonparanoid schizophrenia patients were structurally impaired in the left hemisphere, they would be expected to show a left hemisphere inferiority for letter naming, which was not the case. Nonparanoid schizophrenia patients can process letters in the left hemisphere as well as controls and with the same degree of lateralization (Magaro, 1980). Thus, it appears to be an information processing deficiency.

The callosal transfer hypothesis has received even less support than the left hemisphere dysfunction hypothesis and the precise nature of the dysfunction remains unclear (David, Minne, Jones, & Harvey, 1995). Speculations resulted following a postmortem study showing thickened corpus callosa in chronic schizophrenia patients (Rosenthal & Bigelow, 1972). This was followed by numerous behavioral, physiological, and anatomical studies examining callosal function and size. Raine et al. (1990) reviewed 10 MRI studies and presented data on a new sample. In all, 6 out of the 11 studies showed abnormal callosal dimensions in schizophrenia subjects, and out of these, 4 studies had at least a subgroup with thicker or longer callosa. As for functional measures, many researchers have looked specifically for evidence of disconnection (David, 1993). According to David (1993), the reasons for this are, first, that split-brain patients have occasionally been observed to exhibit psychotic behavior. Second, that a vast body of experimental research has been performed with these individuals,

providing a reliable data base of the effects of cerebral disconnection (Benson & Zaidal, 1985). Although a few studies have suggested some limited disconnection as inferred from reduced transfer of visual and tactile information in schizophrenia patients (Beaumont & Dimond, 1973; David, 1987), other studies have not found this (Raine, Andrews, Sheard, Walder, & Manders, 1989).

Beaumont and Dimond (1973) first suggested callosal transfer difficulties in schizophrenia when they demonstrated that response accuracy declined on bilateral compared to unilateral presentations of a matching paradigm. The divergent results on the callosal transfer studies suggest that bilateral presentation increases the sensory processing and attentional load beyond what schizophrenia patients can tolerate, and rather than interhemispheric communication deficits, the schizophrenia patient's visual processing capacity breaks down due to overload (Walker & McGuire, 1982).

It would appear that studies which have used only one measure of laterality may not have assessed the same function as reported by others unless the identical paradigm was used. Until replications within and across measures are established in schizophrenia, it is overly simplistic to conclude that structural hemispheric dysfunction or callosal transfer deficits are present.

Schizotypy and Asymmetries

It appears that few studies have used a dichotic listening or dichoptic viewing paradigm to uncover hemispheric asymmetries in schizotypal individuals. Studies comparing first-degree schizotypal relatives to schizophrenia probands or to normal controls have yet to be conducted. Some studies have been done on individuals who are schizotypal, but the subjects were always drawn from a normal population, without any relatives with

schizophrenia. For example Broks (1984) examined 36 normal dextral subjects, 18 of each sex, with a divided visual field syllable identification task. Subjects were also rated for schizotypy personality. Male subjects showed a significant correlation between schizotypy and visual field advantage in the direction of an attenuation of the expected left hemisphere advantage to the point of equipotentiality in some subjects. These results are compatible with a shift in hemispheric balance away from the left hemisphere.

Rawlings and Claridge (1984) contrasted normal subjects classified as high and low schizotypy based on a median split in their performance on a divided visual field, letter identification task. High scorers showed a left visual field, right hemisphere advantage while low scorers showed the opposite laterality. High scorers also showed superior performance in their preferred left visual field than low scorers did in the right visual field.

In summary, the question of hemispheric asymmetry in first-degree relatives and in individuals with schizophrenia has not yet been answered. Methodological inconsistencies are a problem in comparing studies of schizotypy and hemispheric asymmetries. These studies do not compare response accuracy or RTs of schizotypal individuals with normal controls or schizophrenia patients, nor have they used both the familiar (letter) and unfamiliar (polygon) stimuli in the tasks. Another obvious shortfall is the lack of studies using first-degree relatives of individuals with schizophrenia (particularly schizotypal first-degree relatives). The present study addresses these issues, and is outlined in the next section.

The Present Study

The previous sections attest to a dramatic growth in the literature on the relationship between abnormal neural development and cognitive deficits in individuals with schizophrenia and their first degree relatives. However, performance in the cognitive domain of memory scanning for individuals with schizophrenia and their first-degree relatives has not been addressed to date. In addition, the relationship of hemispheric lateralization between schizophrenia probands and their first-degree relatives has received little attention. One of the goals of the present study therefore, is to assess the performance of schizophrenia patients, their first-degree relatives, and psychiatric and normal control groups to ascertain if any differences exist in memory scanning performance and hemispheric lateralization.

A second aspect of this study is to explore performance similarities between schizophrenia patients and their family members. First-degree biological relatives of individuals with schizophrenia have a risk of developing schizophrenia about 10 times that of the general population (Kendler & Diehl, 1993). This implies that the relatives have a greater predisposition for the illness than the general population. Studies of schizophrenia show elevated rates of SPD in family members, suggesting a genetic connection (Kety et al., 1994; Kendler et al., 1994). The present study will explore the possibility that greater homogeneity exists on the cognitive measures employed in this research among schizotypal first-degree relatives and their schizophrenia probands than among nonschizotypal first-degree relatives and their schizophrenia probands. It is anticipated that the present study may not only allow researchers to gain critical insights into the nature of certain information processing deficits found in

schizophrenia patients and their family members, but also provide more specific markers of schizophrenia spectrum disorders.

Memory Scanning

The Sternberg memory scanning task (1966, 1969a) will be utilized to investigate cognitive processes in short-term memory. The procedure illuminates the nature of retrieval from short-term memory (a memory search). In this study, the use of the Sternberg paradigm allows an estimate of the time taken to search the items in memory. This is known as the slope of the reaction time/set-size function. In addition, the Sternberg model allows an assessment of the time taken to encode the stimulus, decide, and respond. This is known as the intercept for the reaction time/set-size function.

A review of the literature indicates that this study is the first of its kind, involving both schizophrenia patients and their first-degree relatives. Understanding short term memory processing of individuals with schizophrenia can highlight memory scanning atypicalities. abnormalities, which may contribute to an information processing deficit. Furthermore, discovering the similarities and differences between schizophrenia patients and their first-degree relatives, in particular, schizotypal first-degree relatives, has implications for understanding the core deficits of schizophrenia, as well as shedding light on the familial nature of schizophrenia.

Hemispheric Lateralization

In addition to the investigation of short term memory processing, a great deal of research has been directed to atypical hemispheric lateralization as a potential contributor to the efficiency of information processing. The focal issue highlighted by this research is whether schizophrenia can be linked to

dysfunction in a particular cerebral hemisphere. In an attempt to isolate the locus of hemisphere dysfunction, this study employs a comprehensive experimental design to consider the right and left hemispheres separately, as well as in relation to each other. This addresses the concern of whether one or both hemispheres are functioning atypically. This study will employ both verbal and nonverbal dichotic listening and dichoptic viewing tasks, providing converging data for accurate interpretations of hemispheric relationships (Wexler, 1986). The stimulus-pair/probe-stimulus procedure will be employed to allow for a comparison of verbal (consonant-vowels; letter) and nonverbal (tones; polygons) stimuli. This procedure also allows for a comparison of performance accuracy and reaction times across the auditory and visual modalities.

Research Questions

This research will examine the performance of schizophrenia patients, their first-degree relatives, and psychiatric and normal control groups to ascertain if any differences exist in memory scanning performance and hemispheric lateralization. In addition, this study will explore the performance congruence between schizophrenia patients, and their schizotypal and nonschizotypal first-degree relatives by addressing the following questions:

1) Is there a significant difference in memory scanning rate (ms per item) (slope) among the participant groups?
2) Is there a significant difference in memory scanning for encoding the stimulus, making the decision, and executing the response (intercept) among the participant groups?

3) Are schizotypal first-degree relatives more similar to their schizophrenia probands relative to nonschizotypal first-degree relatives and their schizophrenia probands for memory scanning (ms per item)?
4) For the dichotic listening tasks, are the participant groups typically or atypically lateralized?
5) Are schizotypal first-degree relatives more similar to their schizophrenia probands relative to nonschizotypal first-degree relatives and their schizophrenia probands for their lateralized performance on the dichotic listening task?
6) For the dichoptic viewing tasks, are the participant groups typically or atypically lateralized?
7) Are schizotypal first-degree relatives more similar to their schizophrenia probands relative to nonschizotypal first-degree relatives and their schizophrenia probands for their lateralized performance on the dichoptic viewing task?

CHAPTER III

METHOD

Ethical Considerations

Ethical approval for the current study was obtained from the Conjoint Medical Ethics Committee of the Faculty of Medicine, University of Calgary. All participants were first contacted and presented with an information sheet (Appendix A) or had an information session concerning the nature of their involvement. All participants were informed about the right to withdraw from the study at any time and signed a consent form (Appendix B). If schizophrenia participants were recruited without family members being present, permission was obtained to contact family members (Appendix C). Confidentiality was assured by assigning a code number to each participant at the time of assessment. Forms and questionnaires were only identified by the participant's code number. Only one list of code numbers and names of participants was maintained and stored in a locked office.

Participation took place in Room 288, Special Services Building, of the Foothills Hospital, Calgary, Alberta. Subjects participated in two sessions, each lasting approximately 2 hours, with 1 week between sessions. During each session, at least 1 break was given, and participants were allowed more breaks as needed, therefore fatigue should not have been a factor.

Subjects

Schizophrenia participants. A total of 30 patients with schizophrenia completed participation in this study. They were recruited from the Foothills Hospital Adult Outpatient Program, the Progressive Treatment Unit, and through the Schizophrenia Society, Calgary Chapter. These participants met the

DSM-IV criteria for schizophrenia and received the Structured Clinical Interview for DSM-IV (SCID) to confirm diagnosis. A senior psychiatrist was responsible for completing the SCID and all other assessment scales for individuals with schizophrenia.

First-degree relatives. The relatives who completed participation in this study were 37 first-degree relatives of the completed schizophrenia probands. They were recruited through the Foothills Hospital schizophrenia probands and through the Schizophrenia Society, Calgary Chapter, on a voluntary basis to participate in the study. Schizotypy, as described in the introduction, was measured by the Schizotypal Personality Scale (STA; Claridge & Broks, 1984), a 37 item, self-rating scale based upon the DSM-III-R criteria for schizotypal personality disorder (Appendix D). First-degree relatives were assessed as being schizotypal or nonschizotypal by a median split of the Schizotypal Personality Scale. Grouping first-degree relatives into a low scoring group (nonschizotypal group) and a high scoring group (schizotypal group) was deemed the most useful and efficient method for uncovering differences within the relative group. The median split procedure is easy to apply, commonly used, and has been employed successfully in previous research concerning first-degree relatives of schizophrenia patients (Beech, Baylis, Smithson, & Claridge, 1989; Beech, McManus, Baylis, Tipper, & Agar, 1991).

Nonpsychiatric controls. The 20 nonpsychiatric control participants who completed participation in the study were recruited on a voluntary basis through word of mouth and were screened for the absence of personal or family history of psychiatric disorders.

Psychiatric controls. A psychiatric control group of 15 individuals with

anxiety disorders completed participation in this study and were recruited from Psychiatric Assessment Services at the Foothills Hospital. They were invited to participate on a voluntary basis. Members of this group were diagnosed by both a psychologist and a psychiatrist, from the Psychological Assessment Services of the Foothills Hospital as having an anxiety disorder using DSM-IV criteria.

Criteria

Age. Participants were 18 years of chronological age or older (Appendix E).

Verbal intelligence. Verbal intelligence of all participants (Appendix E) was measured by the Vocabulary Sub-test of the Wechsler Adult Intelligence Scale (Revised). Vocabulary is generally considered to be less affected by psychopathology than other measures of intelligence (Yates, 1966). Subjects with an IQ below 80 were excluded from the study.

Handedness. The handedness of each participant was assessed by way of active demonstration (i.e., participants were asked to show how they combed their hair, brushed their teeth, and how to write a note). Subjects who were not left or right hand dominant (i.e., if both hands used during active demonstration) were excluded from the study. Four schizophrenia participants were excluded due to mixed handedness and did not participate in this study.

Auditory sensitivity. Prior to the experimental sessions, each subject was assessed for auditory sensitivity using a MAICO Advanced Diagnostic Audiometer (Model MA 39) at frequencies ranging from 125 Hz to 8000 Hz. Air-conducting audiometry was used and audiograms were constructed showing the dB threshold for each subject's right and left ear at each of the test frequencies. Subjects demonstrating right/left ear differences of 11 dB or greater and/or a

hearing loss of 25 dB at any of the frequencies were excluded from the study. Eleven schizophrenia patients, 3 nonpsychiatric controls, and 3 first-degree relatives were excluded due to hearing loss and did not participate in this study.

Visual acuity. Each subject was also assessed for near binocular visual acuity employing a Bausch and Lomb Master Ortho-Rater (No. 71-21-40-65). Those subjects for whom near binocular visual acuity was poorer than a Snellen rating of 20/33 were excluded from the study. One schizophrenia participant was excluded due to poor visual acuity and did not participate in this study.

All participants completed a memory scanning task, a dichotic listening task and a dichoptic viewing task.

Memory Scanning Task

The choice of Sternberg's memory scanning task (1966, 1969a) for assessing memory scanning ability was deemed the most appropriate method for research in this area of memory function. The stimuli employed in the task mirrors stimuli that were employed successfully in previous research concerning scanning rates and other patient populations such as aphasics (Swinney & Taylor, 1974) and patients with closed head injuries (Schmitter-Edgecombe, Marks, Fahy, & Long. 1992). In addition, the stimuli employed in this study are known to be the least demanding and fastest to process (Sternberg, 1969b) therefore not burdening the participants with a difficult task.

Stimuli and Apparatus

The stimuli employed in this task were presented on the monitor of a Macintosh IIci computer and consisted of English Letters (excluding I, O, U, and X) and Chinese Characters. The text type of the letters was Helvetica and they were approximately 2 cm x 2 cm in size. The Chinese Characters were

DeskPaint™ pict images of scanned (300 dpi) photocopied (130% enlargement) slides and were also approximately 2 cm x 2 cm in size. The letters and characters were black in color and presented on a white background. The stimuli were arranged in horizontal arrays consisting of one, two, three, or four items.

VScope™, a software program developed by Resnick and Enns (1992), controlled stimuli sequencing and tachistoscopic exposure intervals. Calibration of the visual display was completed with a photodiode and an Iwatsu Digital Storagescope (Model DS 6121). The VScope™ program also collected (within +/- 8 ms accuracy) and stored subject response data.

The monitor of the computer was elevated 29.7 cm from the surface of the 70 cm table on which it rested. A viewing distance of 50 cm was maintained with the aid of a chin rest. The response panel had the same design and specifications as that used in the memory scanning task with one exception; the labels indicated "SAME" or "DIFF" rather than "YES" or "NO".

The monitor of the Macintosh (12" RGB) was elevated 29.7 cm from the surface of the table on which it rested. The table itself was 70 cm high. A black wooden response panel, fitted over the Macintosh keyboard, was positioned approximately 27.4 cm directly in front of the seated subject. The response panel was 42 cm x 16.5 cm and housed two black plastic response keys. The keys were located 8.7 cm from the top of the panel and separated horizontally by 13.6 cm, with the left key being 7.7 cm from the outer edge of the panel and the right key being 17 cm from the outer edge of the panel. The upper surface of each key was 1.27 cm x 1.27 cm and had a slight indentation to accommodate the index finger. Key depression was approximately .50 cm to contact and required very little pressure. A white label with black letters indicating "YES" or "NO" was situated

immediately below each key. For any given subject the same key was labeled "YES" and the alternate key labeled "NO" for all trials. "YES" and "NO" key positions where changed for each subject in order to counterbalance possible effects of hand dominance.

A chin rest was positioned 50 cm from the computer monitor with the height adjusted for each subject just prior to the task.

Procedure

The memory scanning task was administered in one session, lasting approximately 40 minutes. The first half of the session involved the letter stimuli, and the second half of the session involved the Chinese character stimuli. The session involved the learning and testing of each of the four set sizes in ascending order. All acronyms and abbreviations were avoided. Once a letter/character had been used as a probe (from the memory set), it was not employed as a distracter (i.e., an item not from a memory set). An attempt was also made to balance the number of times a distractor was presented across the four set size conditions. On average, a distractor appeared seven or eight times. The number of probes and distractors within a set, however, was balanced and randomized.

The tasks were conducted according to the fixed set procedure (Sternberg, 1969a) where the subject was trained with the memory set before performing the experimental trials. The memory set consisted of one, two, three, and four item arrays of verbal (letters) and nonverbal (Chinese characters) stimuli in block format. Training involved a display of the memory set followed by the administration of practice trials once the set had been learned. The practice trials consisted of 5 repetitions of each of the positive probe items together with a

balanced number of distractors. Visual feedback in the form of (+) signs for correct responses, and (-) signs for incorrect responses, was given during these trials. Before continuing to the experimental trials, subjects were required to achieve a high level of accuracy on the practice trials (e.g., 95%). There were 40 experimental trials administered for each set size.

Each trial began with a 2 second warning dot accompanied by a 50 ms 1127 Hz tone presented at 70 dB. This was followed by the probe item which remained on the screen until a response key was depressed or 4 sec had elapsed. Reaction time, measured in milliseconds, corresponded to the interval between probe onset and response registration.

The following instructions were given to the subject:

> I am now going to show you some letters/Chinese characters which will appear on the screen in front of you. The letters/Chinese characters will consist of sets. For example, the largest set I will ask you to memorize consists of four letters/Chinese characters. The other sets consist of one, two, and three letters/Chinese characters. When you feel you have learned the letters/Chinese characters, you will be presented with a series of single letters/Chinese characters. You will see these letters/Chinese characters one at a time, and you have to determine, as quickly as you can, whether the single letter/Chinese character presented is one of the letters/Chinese characters that you were asked to memorize.
>
> If the letter/Chinese character is a member of the memorized set of letters/Chinese characters, you press this key

(indicate YES key), and if the letter/Chinese character is not from the memorized set, you press this key (indicate NO key). After you have pressed a key, another letter/Chinese character will appear on the screen.

Prior to each single letter/character being presented to you, a dot, accompanied by a beep, will appear in the center of the screen directly in front of you. I want you to look directly ahead at that dot, and keep looking directly ahead even after the dot disappears.

The Dichotic Listening Task

Dichotic listening studies in schizophrenia have made extensive use of consonant vowels (CVs) (e.g., Green, Hugdahl, & Mitchell, 1994) and tones (e.g., Johnson & Crockett, 1982) as stimuli. Consonant vowels (CVs) and tones were employed in this study as stimuli for the dichotic listening task because they are considered as the least demanding stimuli available for assessing auditory hemispheric asymmetries and are less complex than other stimuli (Bruder, 1983). The use of CVs and tones permit greater control over spectral similarity, and it is thereby possible to construct tasks in which the stimulus pairs are perfectly fused. An important methodological advantage of using perfectly fused stimuli is that selective attention to one ear has little or no effect on performance (Repp, 1977), whereas this is certainly not the case for unfused stimuli. Stimuli that fuse to form a single percept also provide a way of minimizing the influence of memory load and response strategy in dichotic listening studies with schizophrenia patients (Colbourn & Lishman, 1979). A description of CV and tone stimuli utilized in this study is presented in the following section.

Speech Stimuli

The speech stimuli employed in this task were recorded from a metal cassette tape containing an adult male's productions of the consonant-vowel (CV) combinations /pa/, /ba/, /ta/, /da/, /ka/, and /ga/. The CVs on the tape were recorded at 10,000 samples/sec., low-pass filtered at 4800 Hz, and equated for overall intensity. In the transfer of the recordings from the tape to a sound file on a Macintosh IIci computer, the original levels of the signals were maintained. For purposes of the present study, however, the signals were edited to a duration of 255 ms.

In an attempt to avoid stimulus dominance effects described by Speaks, Carney, Niccum, and Johnson (1981), not all possible paired combinations of these six CVs were generated for the dichotic pairs. Control for dominance of velar place over bilabial and alveolar place, and voiceless stops over voiced stops resulted in the creation of only four usable pairs: /pa-ta/, /pa-ka/, /ta-ga/, and /ba-da/. Employing a dichotic pair-single probe stimulus technique, each of these pairs was coupled with another CV where half the probes were the same as one member of the dichotic pair and half were different. The "same" probes were distributed randomly and equally across each channel. The concern for dominance effects was also taken into consideration in the selection of the probes. The "different" probes did not differ, acoustic-feature wise, more significantly from one member of the dichotic pair than from the other member. The number of distinct dichotic speech trials generated was 16. These 16 trials were then counterbalanced across channels to produce a block of 32 trials. The 32 trials were then arranged into 4 blocks for a total of 128 trials. Each block was individually randomized, and then held constant across subjects. In the

administration of the task, there was a one minute interval between each block of 32 trials.

Tone Stimuli

The tone stimuli employed in this task were generated by a VAX 11/730 computer and corresponded to the simple tones C (264 Hz), D (297) Hz, F (352 Hz), G (396 Hz), A (440 Hz), and B (495 Hz). The tones were 255 ms in duration and were equated for overall intensity. Pairings were created such that the difference between the members of the dichotic pairs was approximately equal. Working within this criterion, a set of four pairs with a 88-99 Hz difference was created. These pairs were C (264 Hz) with F (352 Hz), D (352 Hz) with G (396 Hz), F (352 Hz) with A (440 Hz), and G (396 Hz) with B (495 Hz). The frequency difference between the "different" probes and either member of the dichotic pair ranged from 44 - 198 Hz. Sixteen distinct dichotic tone trials were generated for the dichotic pair-probe stimulus technique, which, when balanced for channel distribution, yielded 32. These 32 trials, in turn, were arranged into four blocks totaling 128 trials with each block individually randomized and then held constant across subjects. In the administration of the task, there was a one minute interval between each block. Again, half the probes were the same member of the dichotic pair and one half different. The "same" probes were distributed randomly and equally across each ear.

Apparatus

The dichotic tasks were administered under the control of a Macintosh IIci computer. In conjunction with a MacAdios interface board, a computer program, written in Think C language, was developed to execute and control the two-channel output of the dichotic pair and probe. Following parameters

specified in a control file, the program regulated the order of stimulus presentation as well as the interstimulus interval (ISI=500 ms) and intertrial interval (ITI=4000 ms). The program also collected and stored subject response data.

The stimuli were heard through KOSS Pro/4XL headphones connected to an Amacron D-75 amplifier. Sound pressure level was adjusted to approximately 70 dB across the headphones as measured by a Bruel & Kjaer sound-level meter (Model 2218).

For the dichotic listening task, subjects were seated comfortably at a table. A black wooden response panel (30.4 cm x 25.1 cm with a 5.5 cm angled rise), which housed two white response keys labeled "SAME" or "DIFFERENT", was placed on the table in front of the participant. The keys were separated horizontally by 13.7 cm, with each being 7.5 cm from the top, 16.4 cm from the bottom, and 6.6 cm from the outer edge of the panel. Across the table on the wall facing the subject was a large color poster of a mountain scene. "SAME" and "DIFFERENT" key positions where changed for each subject in order to counterbalance possible effects of hand dominance. Task order (CVs/Tones) were changed for every participant in order to counterbalance the possible performance effects of task order.

Procedure

A dichotic pair-single probe technique was employed in this study. The dichotic tasks were administered in one session, lasting approximately 30 minutes. Half of the session involved the speech stimuli, and the other half involved the tone stimuli. Half the subjects listened to the speech stimuli first;

the other half listened to the tone stimuli first. The following instructions were given to the subjects:

> The first thing you are going to hear are two different sounds at exactly the same time. Immediately following this, you are going to hear another sound. Your task will be to determine, as quickly as you can, whether the later sound is the same as or different from either of the earlier sounds.
>
> If you feel the later sound is the same, you press the "same" key (appropriate key indicated), and if you feel the later sound is different, you press this "different" key (appropriate key indicated). After you have pressed a key, another trial will begin. This means you will once again hear two different sounds at exactly the same time, followed quickly by another sound. I want to emphasize that you should make your responses as quickly as possible. If you are not sure, feel free to guess. In any event, you should make a response quickly. The trials will automatically follow one another with very little time between each of them.

After questions were answered, the subject was placed under headphones and 10 practice trials were administered. The practice trials consisted of 5 "same" and 5 "different" trials. While completing the practice trials, the experimenter provided verbal feedback on the correctness of the subject's responses. Before continuing to the experimental trials, subjects were required to achieve a high level of accuracy on the practice trials. Reaction time, measured in milliseconds,

corresponded to the interval between probe onset and response registration.

The Dichoptic Viewing Task

Dichoptic viewing studies have made extensive use of letters and polygons as stimuli (cf. Goldberg & Seidman, 1991). Letters and polygons were employed in this study as stimuli for the dichoptic viewing task because they are considered to be reliable stimuli for assessing hemispheric asymmetries and are less challenging than other stimuli (e.g., perceptually degraded, masked, etc.) (Beaton, 1986). Polygons from the pool scaled by Vanderplas and Garvin (1959) served as the unfamiliar stimuli, and were considered as average complexity. A description of letter and polygon stimuli utilized in this study is presented in the following section.

Familiar Stimuli

The familiar stimuli consisted of English Letters excluding I, O, U, and X. The letters were printed in black Helvetica script and presented on a white background. The task employed a dichoptic pair-single probe technique, which consisted of letters arranged into same-stimulus pairs and then coupled with other letters and which served as probes. Half the probes were the same as one member of the dichoptic pair and half were different. The "same" probes were distributed randomly and equally across each visual half field. All acronyms and abbreviations which contained two to three letters were avoided in the letter dichoptic pair-single probe formations. Each letter in a dichoptic pair subtended a visual angle of 2 degrees. The stimuli were viewed from a distance of 50 cm, and the inside edge of each letter in a dichoptic pair was displaced 2.2906 cm from fixation. A total of 128 trials, divided into 4 blocks of 32 trials each, were administered to the subject. The blocks were individually randomized and then

held constant across subjects. In the administration of the task, there was a one minute interval between each block.

Unfamiliar Stimuli

The unfamiliar stimuli consisted of modified versions of 12 point polygons from the pool scaled by Vanderplas and Garvin (1959). The outline of the polygons was black and they were presented on a white background. The stimuli were viewed from a distance of 50 cm, and the inside edge of each polygon in a dichoptic pair was displaced 2.2906 cm from fixation. The unfamiliar stimuli followed the identical dichotic pair-single probe technique, as employed with the familiar stimuli described above.

Apparatus

The stimuli employed in this task were tachistoscopically presented on the 12 inch monitor of a Macintosh IIci computer. VScope™, a software program developed by Resnick and Enns (1992), controlled stimuli sequencing and tachistoscopic exposure intervals. Calibration of the visual display was completed with a photodiode and an Iwatsu Digital Storage (Model DS 6121). The VScope™ program also collected (within +/- 8 ms accuracy) and stored subject response data.

The monitor of the computer was elevated 29.7 cm from the surface of the 70 cm table on which it rested. A viewing distance of 50 cm was maintained with the aid of a chin rest. The response panel had the same design and specifications as that used in the memory scanning task with one exception; the labels indicated "SAME" or "DIFFERENT" rather than "YES" or "NO". "SAME" and "DIFFERENT" key positions where changed for each subject in order to counterbalance possible effects of hand dominance. Task order

(Letters/Polygons) were changed for every participant in order to counterbalance the possible performance effects of task order.

Procedure

The dichoptic tasks were administered in one session, lasting approximately 40 minutes. One half of the session involved the letter stimuli, and the other half of the session involved the polygon stimuli. Half the subjects viewed the letter stimuli first; the other half viewed the polygon stimuli first.

Each trial began with a 2 second central fixation dot accompanied by a 50 ms, 1127 Hz tone. This was followed by the 100 ms presentation of the dichoptic pair, which, in turn, was followed by the central presentation of the 100 ms probe. Reaction time, measured in milliseconds, corresponded to the interval between probe onset and response registration. The following instructions were given to the subject:

> The first thing you will see is a dot at the center of the screen which is accompanied by a beep. I want you to look directly ahead at that dot, and I want you to keep looking directly ahead even after the dot disappears. Next, you will see two letters/polygons flash on the screen very quickly. After these two letters/polygons have disappeared, a third letter/polygon will flash very quickly at the center of the screen. Your task will be to determine, as quickly as you can, whether the third letter/polygon you saw in the middle of the screen, is the same as or different from either of the first two letters/polygons.
>
> If the third letter/polygon is the same, you press the "same" key (indicate appropriate key) and if the third letter/polygon is

different, you press the "different" key (indicate appropriate key). After you have pressed a key, another trial will begin. Again, the dot will appear in the middle of the screen, followed by another two letters/polygons quickly flashed, followed by a third letter/figure flashed at the center of the screen. I want to emphasize that you should make your responses as quickly as possible. If you are not sure, feel free to guess. In any event, you should make a response quickly. The trials will automatically follow one another with little time between each of them.

After questions were answered, the subject was instructed to place his or her chin on the chin rest and 10 practice trials were administered prior to each (letter/polygon) experimental task. The practice trials consisted of 5 "same" trials and 5 "different" trials. Visual feedback was given in the form of (+) signs for correct responses, and (-) signs for incorrect responses. Before continuing to the experimental trials, subjects were required to achieve a high level of accuracy on the practice trials.

CHAPTER IV

RESULTS

Demographic Variables

The 5 experimental groups (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relative, and Schizotypal Relative) were compared on six demographic variables: age, gender, marital status, education, employment, and verbal IQ. First-degree Relatives were additionally compared on the Schizotypal Personality Scale (STA Scale).

A summary of the means and standard deviations for chronological age and verbal IQ for all participants by group is presented in Appendix E. Analyses of variance revealed that there was a significant difference between the groups with respect to chronological age, $F(6,101) = 19.97$, $p = .001$. As expected, the mean age of the Nonschizotypal Parent group ($M = 56.5$ yrs) and the Schizotypal Parent group ($M = 58.2$ yrs) was significantly higher than the Schizophrenia group ($M = 31.2$ yrs), Psychiatric Control group ($M = 36.6$ yrs), Nonpsychiatric Control group ($M = 32.8$ yrs), Nonschizotypal Sibling group ($M = 36.2$ yrs), and the Schizotypal Sibling group ($M = 34.3$ yrs).

There was also a significant difference in verbal IQ which was assessed by means of the WAIS-R, $F(6,101) = 12.66$, $p = .001$. Vocabulary is considered to be less affected by psychopatholgy than any other measure of intelligence (Yates, 1966). The Schizophrenia group ($M = 94$) had a significantly lower verbal IQ than Nonschizotypal Parents ($M = 121$), the Schizotypal Parents ($M = 111$), and the Schizotypal Siblings ($M = 117$). The Psychiatric Control group ($M = 96$) and the Nonpsychiatric Control group ($M = 99$), was also significantly lower in

comparison with the Nonschizotypal Parent group (M = 121), and the Schizotypal Siblings (M = 117).

Overall, there were 54 males and 48 females in the study (Appendix F). In the Schizophrenia and Nonpsychiatric Control groups, one-quarter were female, in contrast to the preponderance of females in the Psychiatric Control group (80%), the Schizotypal Parent group (78%) and the Schizotypal Sibling group (75%). In the Nonschizotypal Parent and Sibling group, the male/female frequency was balanced.

A breakdown of marital status (Appendix G) indicates that nearly all of the Schizophrenia group (93.3%) and most of the Nonpsychiatric Control group (80%) have never married, compared with the 20% of the Psychiatric Control group, 10% of the Nonschizotypal Relatives, and 11.8% of the Schizotypal Relatives.

Education is summarized in Appendix H. Most of the Schizophrenia participants (67%) and Schizotypal Relatives (65%) received no more than high school education and few received any form of post secondary education. Interestingly, 5.8% of the Schizotypal Relatives received no more than a primary level of education. In contrast, a majority of the Psychiatric Control group (60%) and the Nonpsychiatric Control group (80%) had received post secondary education and 50% of the Nonschizotypal Relative group received some post-secondary education.

The Schizophrenia participant's education was consistent with their low occupational status (Appendix I) and their lower verbal IQ. Of the 30 Schizophrenia participants, as many as 86.7% were unemployed compared with the other groups who ranged from 5% to 33.3%. The Nonpsychiatric Control

group (5%) had the lowest unemployed, and though 30% were students, the remainder were spread over a full range of occupations. In the Psychiatric Control group, apart from 33.3% who were unemployed, the modal category (40%) was clerical/sales/service. Clerical/sales/service was also the modal category (35%) in the Nonschizotypal Relative group with the balance equally distributed over the other levels of occupation. The Schizotypal Relatives had the lowest number of professionals (5.9%) and the highest number of retired (29.4%), the remainder covered the full scope of occupations.

Altogether 30 individuals with schizophrenia participated in the study. The mean length of illness was 10.2 years (SD = 7.6 years). The average daily dosage of the medication they received was 470.11 mg chlorpromazine-equivalent (SD = 407 mg).

Means and standard deviations for the Schizotypal Personality Scale are presented in Appendix J. This scale was administered to the four relative groups only. Analyses of variance revealed that there was a significant difference between the Nonschizotypal and the Schizotypal groups with respect to mean Schizotypal Personality Scale scores, $F(3,36) = 24.86$, $p = .001$. As anticipated, analyses of variance revealed that the score for the Nonschizotypal Parents (M = 4.8) and Nonschizotypal Siblings (M = 5.0) was significantly lower than the score for the Schizotypal Parents (M = 15.5) and the Schizotypal Siblings (M = 14.9).

An assessment of handedness indicates that nearly all of the participants (92%) in the study were right handed. The Psychiatric Control group had the highest amount of left handedness (13%), followed by the Schizophrenia group (12.5%), the Schizotypal Relative group (11.8%), and the Normal Control group (5%). Individuals in the Nonschizotypal Relative group were all right handed.

Memory Scanning

For the memory scanning analyses of variance, the contrast post hoc procedure was employed to examine all main effects (where appropriate). Interaction effects were examined by calculating simple main effects. All tests of statistical significance employed an alpha of $p \leq .05$. The Biomedical (BMD) Program, 4V (1990), and the Statistical Package for Social Sciences, 6.1 (1994) were used for statistical analyses. Only significant main effects and interactions are reported below.

Dependant Measures

Each participant completed 4 blocks of 40 trials with English letters as stimuli, as well as 4 blocks of 42 trials of Chinese characters as stimuli. Block 1 consisted of 1 item to memorize, Block 2 consisted of 2 items to memorize, Block 3 consisted of 3 items to memorize, and Block 4 consisted of 4 items to memorize. Mean reaction time on each Block for each participant was calculated and a regression analysis was conducted to determine slope and intercept of the reaction time/set size function. The slope of the line represents memory scanning rate (ms per item) to search active memory. The intercept represents the combined time (ms) for encoding the stimulus, deciding if a match exists or not between the probe and the items in the memory set, and the time to make a response. These two types of data (slope and intercept) were used as the raw data (dependant measures) for the 2 repeated-measures ANOVAs. Mean linear regression lines for all groups were calculated and presented in Appendix K.

Data Trustworthiness

An error occurred when a participant made a positive response to a "non-set" stimulus or made a negative response to a "set" stimulus. The low error

rates (Table 4.1) were indicative of the fact that participants were highly accurate and were able to memorize the items in the sets, thus maximizing data trustworthiness (Jahnke & Nowaczyk, 1998; Sternberg, 1966).

Table 4.1

Percent of Memory Scanning Errors for the Groups Across Stimulus Type and Response Type

		Memory Scanning Errors					
		Verbal Task		Nonverbal Task		Total Errors	
Group	N	Yes	No	Yes	No	Yes	No
Schizophrenia	30	3.0%	1.6%	3.6%	2.5%	3.3%	2.0%
Psychiatric Control	15	3.3%	1.3%	3.0%	2.4%	3.1%	1.8%
Nonpsychiatric Control	20	2.1%	1.7%	2.8%	1.9%	2.5%	1.8%
Nonschizotypal Parent	13	1.8%	1.3%	2.2%	1.9%	2.0%	1.6%
Nonschizotypal Sibling	7	2.0%	1.8%	2.5%	2.5%	2.2%	2.1%
Schizotypal Parent	10	3.0%	1.9%	4.5%	2.8%	3.8%	2.3%
Schizotypal Sibling	7	2.3%	1.4%	2.7%	0.9%	2.5%	1.2%
Total	102	2.6%	1.5%	3.1%	2.2%	2.9%	1.9%

Scanning Rate (ms per Item) (Slope)

According to Sternberg (1969a), the slope of the regression line represents scanning rate (ms per item) to search active memory. From the regression analysis of reaction time on set-size for each subject in each group, the scanning

rates were computed and then used as the raw data for a Group (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relatives, Schizotypal Relatives) X Stimulus Type (Verbal, Nonverbal) X Response Type (Yes, No) analysis of variance with Stimulus Type and Response Type being repeated measures (Appendix L). Scanning rate (ms per item) means and standard deviations across the 5 groups are presented below in Table 4.2.

Table 4.2

Memory Scanning Rate (ms per item) (Slope) Means and Standard Deviations Across the 5 Groups

	Verbal Stimuli (English Letters)				Nonverbal Stimuli (Chinese Characters)			
	Yes		No		Yes		No	
Group	M	SD	M	SD	M	SD	M	SD
Schizophrenia	36.1	58.9	82.3	126.6	34.8	36.8	79.8	76.4
Psychiatric Control	22.2	22.0	32.5	32.2	40.8	19.8	85.1	66.2
Nonpsychiatric Control	16.1	33.1	29.5	29.3	34.0	49.3	54.7	32.8
Nonschizotypal Relative	13.5	25.3	23.0	22.0	39.9	36.9	84.3	62.8
Schizotypal Relative	12.7	31.8	7.7	45.4	55.4	45.3	88.0	72.4
Mean Total	21.8	40.5	40.6	78.2	40.0	39.2	77.9	64.8

A significant Stimulus Type main effect, $F(1,97) = 24.01$, $p = .001$, was obtained, indicating that memory scanning rates for the Verbal stimuli (M = 27.57 ms) were significantly lower than memory scanning rates for Nonverbal stimuli (M = 59.70 ms). The Response Type main effect, $F(1,97) = 44.37$, $p = .001$,

was also significant. Memory scanning rates for the Yes responses (M = 32.10 ms) were significantly lower than for the No responses (M = 56.71 ms).

A significant Group X Stimulus Type interaction, F(4,97) = 3.15, p = .018, was also obtained (Figure 4.1). For Verbal stimuli, the scanning rate of the Schizophrenia group was significantly slower (M = 59.16 ms) in comparison to that of the Psychiatric Control (M = 27.34 ms), the Nonpsychiatric Control (M = 22.80 ms), the Nonschizotypal Relative (M = 18.32 ms), and the Schizotypal Relative (M = 10.23 ms) groups. There were no group differences found for Nonverbal stimuli.

The Group X Response Type interaction, F(4,97) = 2.54, p = .044, was also significant (Figure 4.2). For accurate No responses, the memory scanning rate of the Schizophrenia group was significantly slower (M = 81.07 ms) when compared to that of the Nonpsychiatric Control group only (M = 42.12 ms). There were no significant group differences found in the Yes response condition.

A significant interaction of Stimulus Type X Response Type, F(1,97) = 5.26, p = .024 was also found (Figure 4.3). For Verbal Stimuli, accurate Yes Responses (M = 20.11 ms) were significantly faster than accurate No Responses (M = 35.01 ms). Likewise, for the Nonverbal Stimuli, accurate Yes Responses (M = 40.99 ms) were significantly faster than accurate No Responses (M = 78.40 ms).

Overall, the findings of the memory scanning rate (slope) ANOVA indicate that the scanning rate for English Letters (M = 27.57 ms) was faster than the scanning rate for Chinese characters (M = 59.70 ms). This was expected because English Letters are more familiar and easier to process than unfamiliar Chinese characters. The Schizophrenia group had a slower scanning rate in comparison to the other groups when Verbal Stimuli (English letters) were

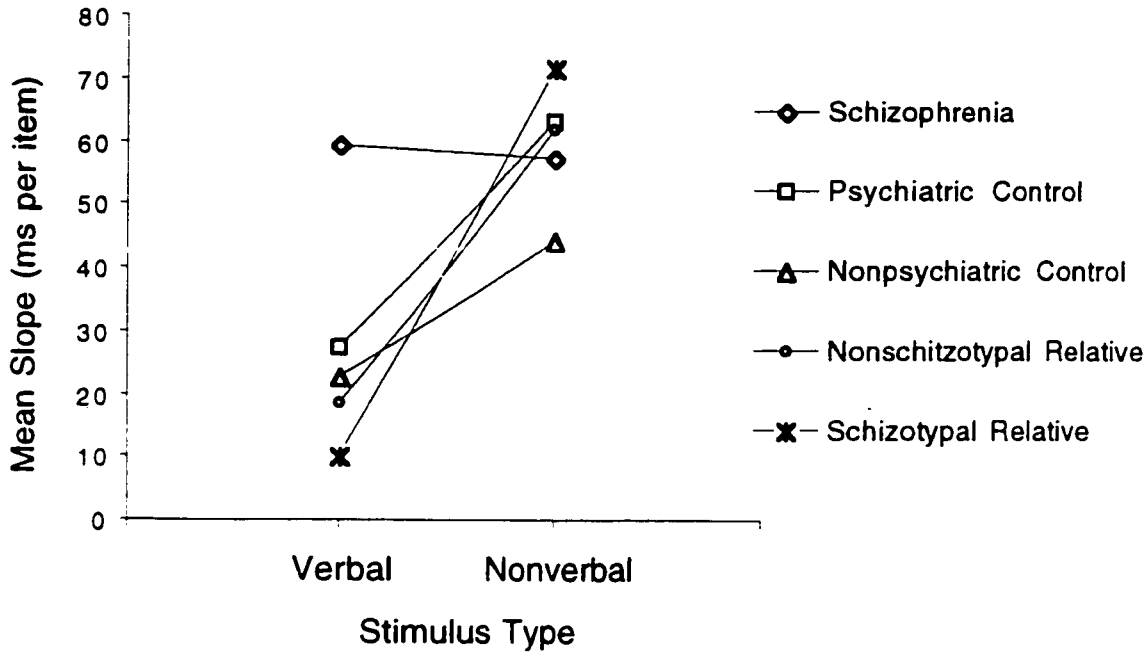


Figure 4.1 Mean Scanning Rate (ms per item) for the Schizophrenia, the Psychiatric Control, the Nonpsychiatric Control, the Nonschizotypal Relative, and the Schizotypal Relative Groups as a Function of Stimulus Type.

Figure 4.2 Mean Scanning Rate (ms per item) for the Schizophrenia, the Psychiatric Control, the Nonpsychiatric Control, the Nonschizotypal Relative and the Schizotypal Relative Groups as a Function of Response Type.

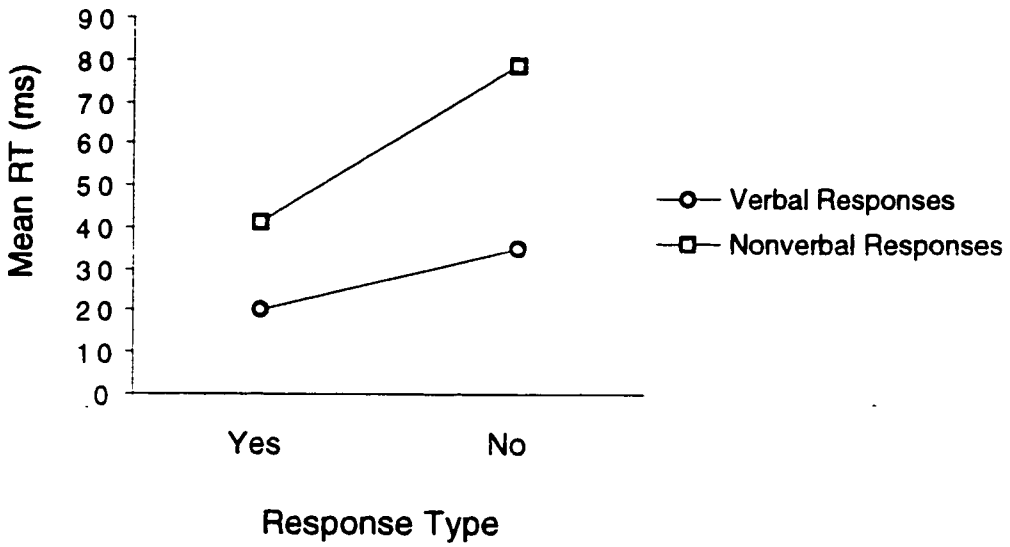


Figure 4.3 Mean Scanning Rate for Verbal and Nonverbal Stimuli for Yes and No Responses.

utilized, and a slower scanning rate when "No" responses were made.

Combined Encoding, Deciding, and Responding Time (Intercept)

The intercept represents the combined time for encoding the stimulus, deciding if a match exists or not between the probe and the items in the memory set, and the time to make a response (Sternberg, 1969a). From the regression analyses of reaction time on set-size, the combined time (intercept values) for each subject in each group was used as the raw data in a Group (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relatives, Schizotypal Relatives) X Stimulus Type (Verbal, Nonverbal) X Response Type (Yes, No) analysis of variance with Stimulus Type and Response Type being repeated measures (Appendix M). Combined encoding, deciding, and responding time (intercept) means and standard deviations across the 5 groups are presented in Table 4.3.

Table 4.3

Combined Encoding, Deciding, and Responding Time (Intercept) Means and Standard Deviations Across the 5 Groups

	Verbal Stimuli (English Letters)				Nonverbal Stimuli (Chinese Characters)			
	Yes		No		Yes		No	
Group	M	SD	M	SD	M	SD	M	SD
Schizophrenia	537.5	181.2	543.7	199.1	594.7	134.1	604.7	222.9
Psychiatric Control	468.9	91.6	504.6	110.1	495.0	137.4	482.3	145.2
Nonpsychiatric Control	462.8	121.0	459.4	104.3	509.7	179.7	513.4	116.3
Nonschizotypal Relative	536.1	96.5	547.2	78.3	547.6	100.6	551.0	137.4
Schizotypal Relative	547.1	153.4	601.5	205.2	514.8	100.4	513.0	138.4

Analyses of variance for the combined time (intercept) data revealed no significant differences.

Memory Scanning Correlations

Intraclass Correlation Coefficients (ICCs) were used to express the fact that observations in the same group are related, or tend on average to be more like each other. The larger the positive coefficient value, the more similar do observations in the same group tend to be. The value of the coefficient, is thus a measure of the homogeneity of observations within a group. ICCs were calculated to investigate the variance of scanning rates (ms per item in memory) among Schizotypal Relatives and their Schizophrenia probands (Table 4.4) and among Nonschizotypal Relatives and their Schizophrenia probands (Table 4.5). The ICC formula is presented in Appendix N. The conditions were mean Verbal Yes, Verbal No, Nonverbal Yes, and Nonverbal No. For a complete description of the correlation calculations, see Model 1, Shrout and Fleiss (1979).

The ICCs for Verbal Yes and Nonverbal No scanning rates (slopes) for the Schizotypal Relatives and their Schizophrenia probands were (.47) and (.62) respectively. This is in sharp contrast to the lower ICCs for Verbal Yes and Nonverbal No scanning rates for the Nonschizotypal Relatives and their Schizophrenia probands which were (.10) and (.22). The ICCs detected greater amounts of homogeneity among Schizotypal Relatives and their Schizophrenia probands than among Nonschizotypal Relatives and their Schizophrenia probands for Verbal Yes and Nonverbal No conditions. The likeness found among Schizotypal Relatives and their Schizophrenia probands indicates these individuals had similar scanning rates. For Verbal No and Nonverbal Yes conditions, the homogeneity was low among both groups.

Table 4.4

Intraclass Correlation Coefficients Among Schizotypal Relatives and Their Schizophrenia Probands for Scanning Rates (ms per item in memory).

Conditions	N	Mean of Ratings
Mean Verbal Yes	34	.47
Mean Verbal No	34	.0
Mean Nonverbal Yes	34	.0
Mean Nonverbal No	34	.62

Table 4.5

Intraclass Correlation Coefficients Among Nonschizotypal Relatives and Their Schizophrenia Probands for Scanning Rates (ms per item in memory).

Conditions	N	Mean of Ratings
Mean Verbal Yes	40	.10
Mean Verbal No	40	.08
Mean Nonverbal Yes	40	.12
Mean Nonverbal No	40	.22

Dichotic Listening Task

For all subsequent analyses of variance, Tukey's honestly significant difference post hoc test procedure was used to examine all main effects (where appropriate). Significant interaction effects were examined by calculating simple main effects. All tests of statistical significance employed an alpha of $p \leq .05$. The Statistical Package for Social Science, 6.1 (1994) was used as the computer program for the following statistical analyses. Only significant main effects and interactions are reported below.

Dependant Measures

Each participant completed 128 trials with CVs as stimuli, as well as 128 trials with Tone as stimuli. Mean accuracy and mean reaction time for each individual was calculated. Group means were generated and became the raw data (dependant measures) for the 2 repeated measures ANOVAs.

Accuracy

The number of correct responses was converted to a percentage which was then subjected to a Group (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relative, Schizotypal Relative) X Stimulus Type (CV, Tone) X Ear (Right, Left) X Block (1, 2, 3, 4) analysis of variance with Stimulus Type, Ear, and Block being repeated measures (Appendix O). Accuracy means and standard deviations for the 5 groups are presented in Table 4.6.

A significant Group main effect, $F(4,97) = 3.08$, $p = .020$, was obtained. Post hoc analyses revealed that performance of the Schizotypal Relative group ($M = 65.44\%$) was significantly poorer than the Psychiatric Control group ($M = 78.02\%$).

Table 4.6

Dichotic Listening Accuracy Means and Standard Deviations Across the 5 Groups

	Verbal Stimuli (Consonant Vowels)				Nonverbal Stimuli (Tones)			
	Right Ear		Left Ear		Right Ear		Left Ear	
Group	M	SD	M	SD	M	SD	M	SD
Schizophrenia	71.5	23.1	60.0	24.8	72.8	19.6	74.0	14.7
Psychiatric Control	80.41	17.7	71.9	21.4	79.2	16.7	80.6	16.3
Nonpsychiatric Control	73.6	18.3	68.3	21.3	72.2	11.1	76.4	15.2
Nonschizotypal Relative	49.8	28.2	75.2	19.2	73.75	15.6	74.4	15.2
Schizotypal Relative	50.0	20.7	69.3	23.2	73.5	13.4	69.0	13.3
Mean Total	65.4	25.0	67.9	22.6	73.9	15.8	74.6	15.0

Stimulus Type main effect, $F(1,97) = 20.38$, $p = .001$, was obtained, indicating that CVs ($M = 66.64\%$) were more difficult than Tones ($M = 74.29\%$). The Group X Stimulus Type X Ear interaction, $F(4,97) = 6.13$, $p = .001$, also reached significance (Figure 4.4). For CV stimulus presentations, Right Ear accuracy revealed that the Schizophrenia (71.46%), Psychiatric Control (80.42%), and Nonpsychiatric Control (73.60%) groups were significantly better than the Nonschizotypal Relative (49.85%) and the Schizotypal Relative (50%) groups.

The Ear X Block interaction, $F(3,582) = 4.34$, $p = .005$, reached significance. For the Left Ear condition, performance across Block 1, 2, 3, and 4, was comparable. Significant Block differences were obtained under the Right Ear condition. Additionally, for Block 1, Left Ear accuracy (72.29%) was significantly better than the Right Ear (65.97%).

Overall, the main finding from the dichotic listening accuracy ANOVA indicates that the two relative groups had dramatically lower right ear accuracy in comparison to the other groups when responding to CV stimuli. An unusual pattern of responding to CV stimuli emerged for both relative groups. They demonstrated a right hemisphere advantage for CV stimuli, when the opposite pattern (left hemisphere advantage) was expected.

Reaction Time

A Group (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relatives, Schizotypal Relatives) X Stimulus Type (CV, Tone) X Ear (Right, Left) X Block (1, 2, 3, 4) analysis of variance with Stimulus Type, Ear, and Block being repeated measures was carried out for the correct response reaction times (Appendix P). Dichotic listening reaction time means and standard deviations across the 5 groups are presented in Table 4.7.

Table 4.7

Dichotic Listening Reaction Times Means and Standard Deviations Across the 5 Groups

	Verbal Stimuli (Consonant Vowels)				Nonverbal Stimuli (Tones)			
	Right Ear		Left Ear		Right Ear		Left Ear	
Group	M	SD	M	SD	M	SD	M	SD
Schizophrenia	1022.3	343.6	1110.0	431.4	1247.8	519.3	1214.4	473.3
Psychiatric Control	744.8	295.3	803.1	334.4	968.1	408.2	914.6	303.7
Nonpsychiatric Control	818.0	233.3	808.0	216.6	869.8	264.7	863.3	285.8
Nonschizotypal Relative	815.5	256.4	736.1	200.3	824.0	300.2	824.6	249.0
Schizotypal Relative	908.8	437.3	874.4	387.3	926.1	277.9	938.5	267.6
Mean Total	881.2	330.8	893.0	361.4	995.9	414.3	979.1	374.4

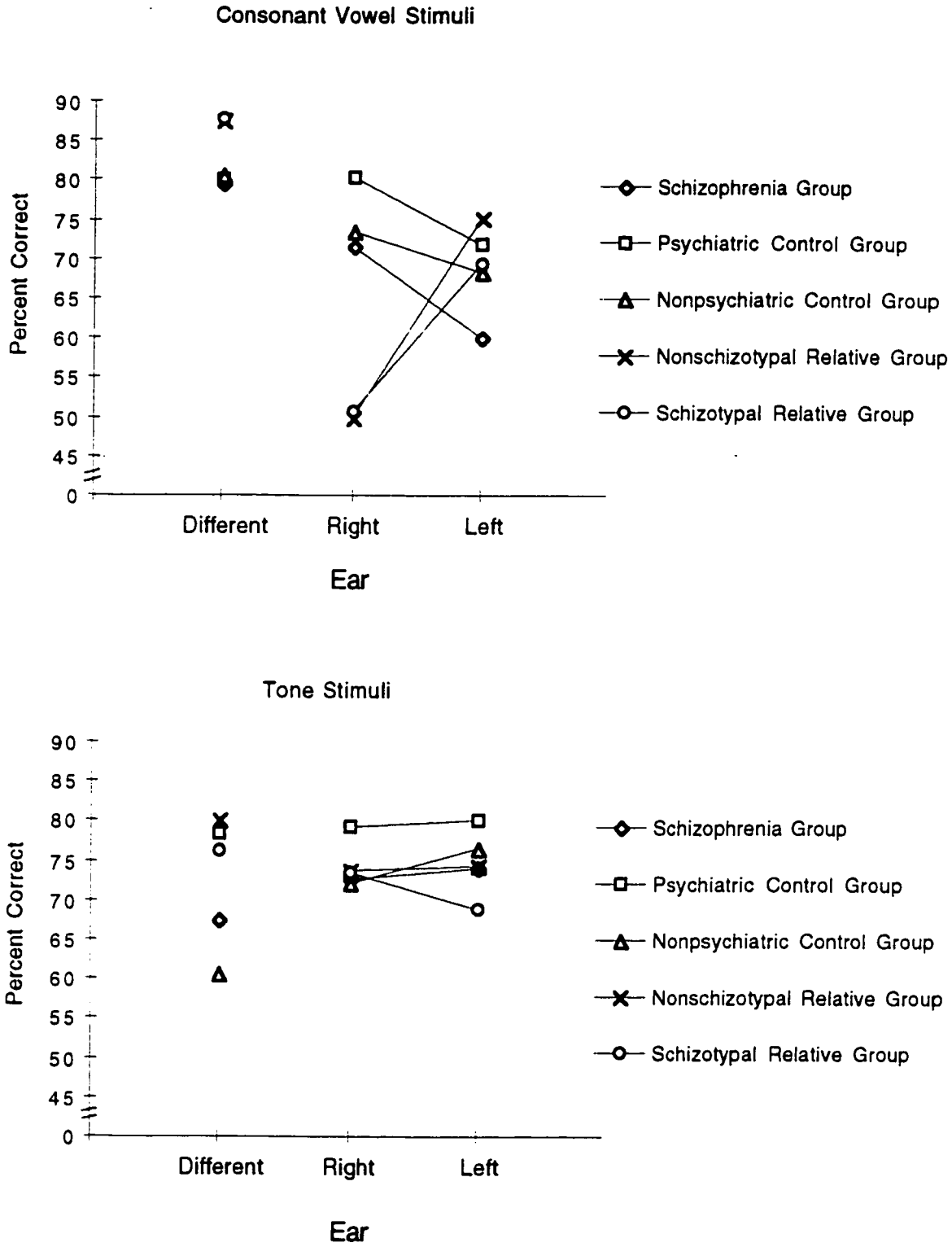


Figure 4.4 Right and Left Ear Accuracy for the Schizophrenia, Nonpsychiatric Control, Psychiatric Control, Nonschizotypal Relative, and Schizotypal Relative Groups as a function of Stimuli Type.

A significant Group Main effect, $F(4,84) = 4.54$, $p = .002$, was obtained. The Schizophrenia group was significantly slower ($M = 1133.13$ ms) relative to the Nonpsychiatric Control group ($M = 857.45$ ms) and the Nonschizotypal Relative group ($M = 764.61$ ms).

A significant Stimuli Type main effect, $F(1,84) = 7.79$, $p = .007$, was also obtained. Reaction times were slower for Tones ($M = 973.64$ ms) than for CVs ($M = 889.17$ ms).

Likewise, the Block main effect, $F(3,252) = 5.67$, $p = .001$, was also obtained. Reaction times were slower for Block 1 ($M = 972.23$ ms) than for Block 3 ($M = 907.89$ ms), and Block 4 ($M = 913$ ms).

The findings from the dichotic listening reaction time ANOVA indicate that a group main effect occurred. The response time of the schizophrenia group was slower in comparison to the other groups. No differences emerged among the groups for dichotic listening reaction time in relation to Stimulus Type or Ear.

Dichoptic Viewing Task

Dependant Measures

Each participant completed 128 trials with English Letters as stimuli, as well as 128 trials with Polygons as stimuli. Mean accuracy and mean reaction time for each individual was calculated. Group means were generated and became the raw data (dependant measures) for the 2 repeated measures ANOVAs.

Accuracy

The number of correct responses was converted to a percentage which was then subjected to a Group (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relative, Schizotypal Relative) X

Stimulus Type (Letter, Polygon) X Visual Field (Right, Left) X Block (1, 2, 3, 4) mixed analyses of variance with Stimulus Type, Visual Field, and Block being repeated measures (Appendix Q). Dichoptic Viewing Accuracy Means and Standard Deviations across the 5 groups are presented in Table 4.8.

A Stimulus Type main effect, $F(1,97) = 142.66$, $p = .001$, was obtained, revealing that accuracy was significantly higher with Letters ($M = 83.70\%$) than with Polygons ($M = 62.55\%$).

A Stimulus Type main effect, $F(1,97) = 142.66$, $p = .001$, was obtained, revealing that accuracy was significantly higher with Letters ($M = 83.70\%$) than with Polygons ($M = 62.55\%$).

Table 4.8

Dichoptic Viewing Accuracy Means and Standard Deviations Across the 5 Groups

	English Letters				Polygons			
	R Vis Field		L Vis Field		R Vis Field		L Vis Field	
Group	M	SD	M	SD	M	SD	M	SD
Schizophrenia	83.0	15.0	83.9	17.9	58.2	22.5	62.7	20.4
Psychiatric Control	83.5	14.4	88.1	16.7	67.9	16.0	77.3	18.7
Nonpsychiatric Control	81.7	15.7	90.5	12.4	67.0	17.3	62.5	25.4
Nonschizotypal Relative	76.6	21.1	87.0	14.5	55.5	23.7	62.2	26.7
Schizotypal Relative	80.1	18.5	83.3	18.1	55.1	22.7	63.1	17.0

The Visual Field main effect, $F(1,97) = 11.24$, $p = .001$, was also attained, demonstrating significantly lower accuracy in the Right Visual Field (M = 70.71%) relative to the Left Visual Field (M = 75.54%).

In addition, the Block main effect, $F(3,291) = 3.82$, $p = .010$, was obtained. Response accuracy in Block 1 (M = 70.56%) was significantly lower than in Block 3 (M = 74.36%), and in Block 4 (M = 74.57%) which did not differ.

The Visual Field X Block interaction, $F(3,291) = 2.70$, $p = .046$, reached significance. Both Visual Fields were significant across Blocks. In addition, the Right Visual Field (M = 68.14%) was significantly less accurate than the Left Visual Field (M = 72.98%) at Block 1.

The findings from the dichoptic viewing accuracy ANOVA indicate that all groups were performing in a similar manner and that no differences emerged among the groups in relation to Stimulus Type or Visual Field.

Reaction Time

A Group (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relatives, Schizotypal Relatives) X Stimulus Type (Letter, Polygon) X Visual Field (Right, Left) X Block (1, 2, 3, 4) analysis of variance with Stimulus Type, Visual Field, and Block being repeated measures was carried out for the correct response reaction times and is summarized in Appendix R. Dichoptic Viewing reaction time means and standard deviations across the 5 groups are presented in Table 4.9.

Table 4.9

Dichoptic Viewing Reaction Time Means and Standard Deviations Across the 5 Groups

	English Letters				Polygons			
	R Vis Field		L Vis Field		R Vis Field		L Vis Field	
Group	M	SD	M	SD	M	SD	M	SD
Schizophrenia	942.0	362.5	830.4	228.6	988.5	249.1	952.8	255.1
Psychiatric Control	710.4	182.7	682.3	178.0	781.8	240.3	760.1	259.9
Nonpsychiatric Control	676.1	121.5	638.8	128.2	788.7	220.4	787.3	246.8
Nonschizotypal Relative	720.4	191.9	679.2	173.3	804.5	381.5	870.2	518.1
Schizotypal Relative	785.0	297.7	708.5	248.5	800.4	139.1	780.61	150.3
Mean Total	786.2	278.2	721.1	208.3	851.5	270.9	847.1	315.2

The main effect of Group, $F(4,85) = 4.48$, $p = .002$, was significant, indicating that the response time of the Schizophrenia group ($M = 905.10$ ms) was significantly slower to respond correctly relative to the Nonpsychiatric Control group ($M = 693.59$ ms) and the Nonschizotypal Relative group ($M = 717.50$ ms).

The main effect of Stimulus type, $F(1,85) = 10.48$, $p = .002$, was also significant revealing that correct response time to Polygons ($M = 820.74$ ms) was significantly slower when compared to Letters ($M = 735.01$ ms).

In addition, a significant Visual Field main effect, $F(1,85) = 6.65$, $p = .012$, was obtained. The response times to stimuli presented in the Left Visual Field ($M = 759.78$ ms) were significantly faster relative to those in the Right Visual Field ($M = 795.97$ ms).

Likewise, a significant Block main effect suggested that response times declined significantly from Block 1 (M = 818.40 ms), to Block 2 (M = 784.96 ms), Block 3 (M = 768 ms), and Block 4 (M = 740.14 ms).

A significant Visual Field by Block interaction, F(3,255) = 4.35, p = .005, was obtained. Correct responses in the Right Visual Field were different across the 4 Blocks, as were responses in the Left Visual Field. Both the Right and Left Visual Field conditions had slowest responses in Block 1 and fastest responses in Block 4. Significance was also reached across the Visual Fields at Block 1, with the Left Visual Field (M = 779.87 ms) being faster than the Right Visual Field (M = 856.94 ms).

The findings from the dichoptic viewing reaction time ANOVA indicate that all groups were performing in a similar manner and that no differences emerged among the groups in relation to Stimulus Type or Visual Field.

Discrimination

The "Different" condition assesses the ability of participants to correctly identify a stimulus (the probe) as being neither presented to the left nor right Ear/Visual Field. Participants are simply asked to judge if the probe differs from the immediate/prior two stimuli. It should be noted that the Different trials were randomly integrated with the lateralization trials (right/left).

Auditory Discrimination

Accuracy. The number of correct responses was converted to a percentage which was then subjected to a Group (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relative, Schizotypal Relative) X Stimulus Type (CV, Tone) X Block (1, 2, 3, 4) analysis of variance with Stimulus Type, and Block being repeated measures (Appendix S).

A significant Group main effect, $F(4,97) = 3.28$, $p = .016$, was obtained. The Schizophrenia group ($M = 73.46\%$) was significantly poorer than the Nonschizotypal ($M = 82.11\%$) and the Schizotypal Relatives ($M = 82.01\%$) who did not differ.

A Stimulus Type main effect, $F(1,97) = 19.83$, $p = .001$, was obtained, indicating that Tones ($M = 74.88\%$) were more difficult than CVs ($M = 82.71\%$).

The Group X Stimulus Type interaction, $F(4,97) = 2.46$, $p = .050$, also reached significance (Figure 4.5). For Tone stimuli, the Schizophrenia group ($M = 67.5\%$) was significantly poorer than the Nonpsychiatric Control group only ($M = 80\%$).

Reaction time. A Group (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relatives, Schizotypal Relatives) X Stimulus Type (CV, Tone) X Block (1, 2, 3, 4) analysis of variance with Stimulus Type, and Block being repeated measures was carried out for the correct response reaction times (Appendix T).

A significant Group Main effect, $F(4,94) = 9.53$, $p = .001$, was obtained. The Schizophrenia group was significantly slower ($M = 1251.56$ ms) relative to the Psychiatric Control ($M = 953.58$ ms), Nonpsychiatric Control ($M = 909.64$ ms), Nonschizotypal Relative ($M = 803.73$ ms), and Schizotypal Relative ($M = 936.43$ ms) groups.

A significant Block main effect, $F(3,282) = 7.27$, $p = .001$, was also obtained. Reaction times were slower for Block 1 ($M = 1036.35$ ms) than for Block 3 ($M = 976.28$ ms) and Block 4 ($M = 987.88$ ms). Similarly, Block 2 ($M = 1015.15$ ms) was significantly slower than Block 3 ($M = 976.28$ ms).

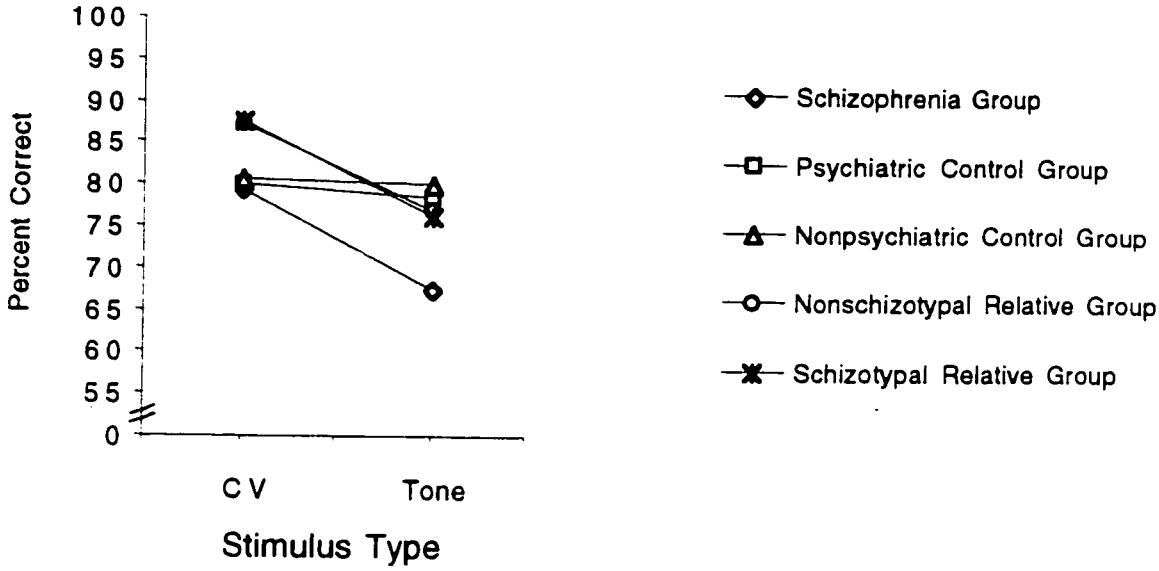


Figure 4.5 Different condition accuracy for the Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relative and Schizotypal Relative Groups as a function of Stimulus Type (CV/Tone).

The Group X Block interaction, $F(12,282) = 1.97$, $p = .027$, reached significance (Figure 4.6). The Schizophrenia group was significantly slower than all other groups for Block 1, Block 2, Block 3, and Block 4.

Visual Discrimination

Accuracy. The number of correct responses was converted to a percentage which was then subjected to a Group (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relative, Schizotypal Relative) X Stimulus Type (Letter, Polygon) X Block (1, 2, 3, 4) mixed analyses of variance with Stimulus Type and Block being repeated measures (Appendix U).

A Group main effect, $F(4,97) = 3.06$, $p = .020$, was obtained. The post hoc analysis did not indicate any significant differences.

The Stimulus type main effect, $F(1,97) = 244.60$, $p = .001$, revealed that accuracy was significantly higher with Letters ($M = 91.62\%$) than with Polygons ($M = 65.64\%$).

The Block main effect, $F(3,291) = 5.56$, $p = .001$, reached significance. Accuracy was significantly lower for Block 1 ($M = 76.04\%$) than for Block 2 ($M = 79.41\%$), Block 3 ($M = 79.11\%$), and Block 4 ($M = 79.96\%$).

The Group X Stimulus type X Block interaction, $F(12,291) = 1.84$, $p = .042$, reached significance (Figure 4.7). For the Letter stimuli at Block 1, the Schizophrenia group ($M = 85.21\%$) was less accurate than the Nonpsychiatric Control group ($M = 94.06\%$). For the Letter stimuli at Block 2, the Schizophrenia group ($M = 87.71\%$) was less accurate than the Schizotypal Relative group ($M = 97.06\%$). For the Polygons at Block 1, the Psychiatric Control group ($M = 52.92\%$) was significantly less accurate than the Nonpsychiatric Control group ($M = 65.31\%$) and the Schizotypal Relative group ($M = 69.12\%$). For the Polygons at

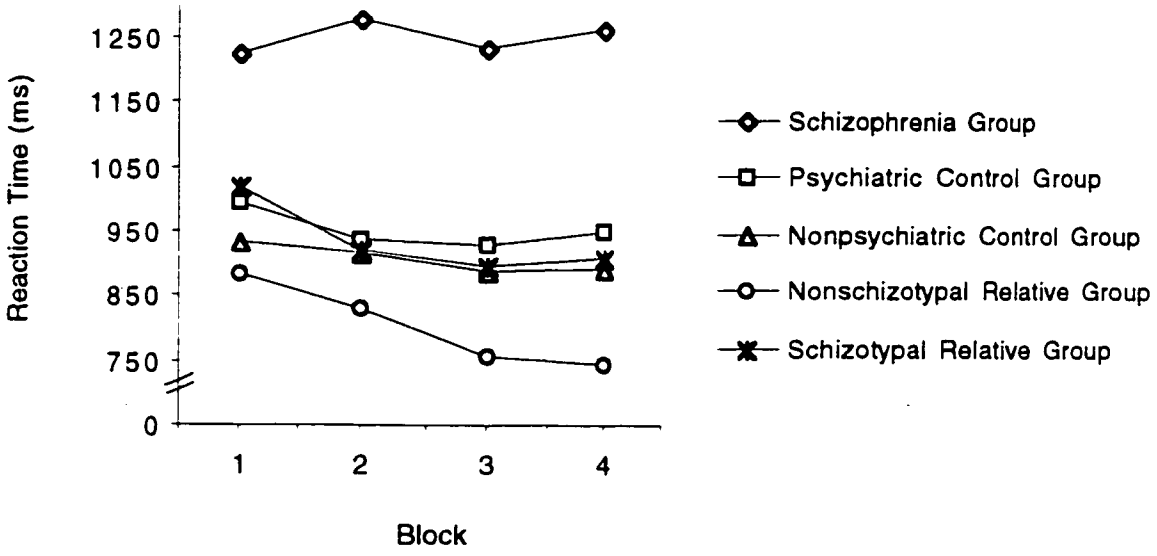


Figure 4.6 Reaction time for correct different responses by the Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relative, and Schizotypal Relative Groups as a function of Block.

Block 2, the Nonpsychiatric Control group (M = 78.75%) was more accurate than the Schizophrenia (M = 61.88%), Psychiatric Control (M = 54.17%), Nonschizotypal Relative (M = 68.44%) and Schizotypal Relative (M = 69.85%) groups. The Psychiatric Control group (M = 54.17%) was less accurate than Nonpsychiatric Control (M = 78.75%), Nonschizotypal Relative (M = 68.44%) and Schizotypal Relative (M = 69.85%) groups. In addition, the Schizophrenia group (M = 61.88%) was less accurate than the Nonpsychiatric Control (M = 78.75%), and Schizotypal Relative (M = 69.85%) groups. At Block 3, the Psychiatric Control group (M = 60.42%) was less accurate than the Schizotypal Relative (M = 72.43%) and the Nonpsychiatric Control (M = 73.13%) groups. In addition, the Schizophrenia group (M = 61.88%) was less accurate than the Nonpsychiatric Control (M = 73.13%) and Schizotypal Relative (M = 72.43%) groups. For Block 4, the Schizophrenia group (M = 61.46%) was less accurate than the Nonpsychiatric group (M = 72.50%).

Reaction time. A Group (Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relatives, Schizotypal Relatives) X Stimulus Type (Letter, Polygon) X Block (1, 2, 3, 4) analysis of variance with Stimulus Type, and Block being repeated measures was carried out for the correct response reaction times and is summarized in Appendix V.

The main effect of Group, F(4,96) = 8.31, p = .001, was significant, indicating that the correct response time of the Schizophrenia group (M = 961.67 ms) was significantly slower relative to the Psychiatric Control group (M = 804.31 ms), the Nonpsychiatric Control group (M = 740.14 ms), the Nonschizotypal Relative group (M = 759.23 ms), and the Schizotypal Relative group (M = 757.07 ms) which did not differ.

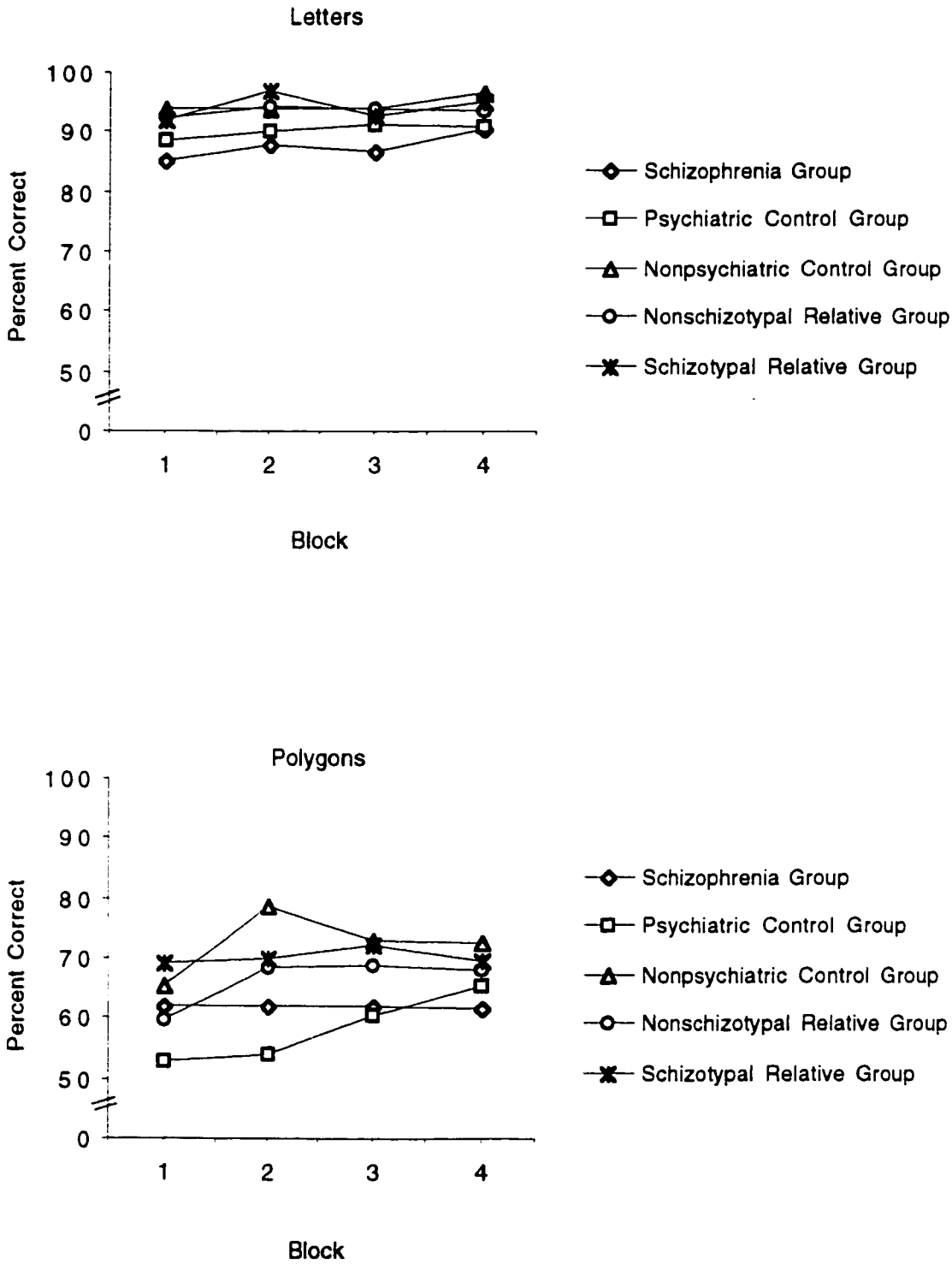


Figure 4.7 Different condition accuracy for the Schizophrenia, Psychiatric Control, Nonpsychiatric Control, Nonschizotypal Relative, and Schizotypal Relative Groups as a function of Stimulus Type and Block.

The main effect of Stimulus, $F(1,96) = 38.03$, $p = .001$, was also significant revealing that correct response time to Polygons ($M = 893.61$ ms) was significantly slower when compared to Letters ($M = 746.20$ ms).

In addition, a significant Block main effect, $F(3,288) = 21.77$, $p = .001$, was obtained, suggesting that response time declined significantly from Block 1 ($M = 876.64$ ms), to Block 2 ($M = 827.89$ ms), Block 3 ($M = 800.14$ ms), and Block 4 ($M = 777.95$ ms).

The findings from the visual and auditory discrimination ANOVAs for accuracy and reaction time indicate that the Schizophrenia group was consistently less accurate and slower to respond in comparison to the other groups.

Dichotic Listening and Dichoptic Viewing Correlations

Intraclass Correlation Coefficients (ICCs) were calculated to investigate the variance of dichotic listening reaction times and accuracy among Schizotypal Relatives and their Schizophrenia probands and among Nonschizotypal Relatives and their Schizophrenia probands (Table 4.10). The ICC formula is presented in Appendix N. For a complete description of the correlation calculations, see Model 1, Shrout and Fleiss (1979).

The ICCs for all conditions in the dichotic listening task revealed greater homogeneity among Schizotypal Relatives and their Schizophrenia probands than among Nonschizotypal Relatives and their Schizophrenia probands.

Further Intraclass Correlation Coefficients were calculated to investigate the variance of dichoptic viewing reaction times and accuracy among Schizotypal Relatives and their Schizophrenia probands and among Nonschizotypal Relatives and their Schizophrenia probands (Table 4.11).

Table 4.10

Intraclass Correlation Coefficients Among Schizotypal Relatives and Their Schizophrenia Probands (n=34) and for Nonschizotypal Relatives and Their Schizophrenia Probands (n=40) for the Dichotic Listening Task.

Condition	ICC for Mean of Ratings for Schizotypal Relatives with Schizophrenia Probands	ICC for Mean of Ratings for Nonschizotypal Relatives with Schizophrenia Probands
Dichotic Listening		
CVs Right Ear RT	.13	.0
CVs Left Ear RT	.0	.0
Tones Right Ear RT	.02	.0
Tones Left Ear RT	.22	.0
CVs Right Ear Accuracy	.0	.0
CVs Left Ear Accuracy	.42	.0
Tones Right Ear Accuracy	.44	.12
Tones Left Ear Accuracy	.41	.05

In sharp contrast to the dichotic listening ICCs, the dichoptic viewing ICCs revealed greater homogeneity among Nonschizotypal Relatives and their Schizophrenia probands than among Schizotypal Relatives and their probands in most conditions. The lateralization ICCs revealed two clear differences: Schizotypal Relatives and their probands are more alike in the auditory modality, and Nonschizotypal Relatives and their probands are more alike in the visual modality.

Table 4.11

Intraclass Correlation Coefficients Among Schizotypal Relatives and Their Schizophrenia Probands (n=34) and for Nonschizotypal Relatives and Their Schizophrenia Probands (n=40) for the Dichoptic Viewing Task.

Condition	ICC for Mean of Ratings for Schizotypal Relatives with Schizophrenia Probands	ICC for Mean of Ratings for Nonschizotypal Relatives with Schizophrenia Probands
Dichoptic Viewing		
Letters Right Visual Field RT	.55	.0
Letters Left Visual Field RT	.0	.28
Polygons Right Visual Field RT	.0	.20
Polygons Left Visual Field RT	.0	.43
Letters Right Visual Field Accuracy	.24	.53
Letters Left Visual Field Accuracy	.0	.43
Polygons Right Visual Field Accuracy	.0	.55
Polygons Left Visual Field Accuracy	.03	.45

CHAPTER V

DISCUSSION

This chapter will compare and contrast the results obtained by the present research with existing literature in the field. Demographic issues pertinent to this sample of participants are the first to be explored. Next, a discussion regarding the associations between the memory scanning findings as they relate to previous research is provided. Following this, the direction of hemispheric lateralization by the participant groups is explored in relation to prior theory. At the end of this chapter, conclusions are drawn and the advantages and limitations of this research are extended in reference to other studies and finally, a discussion regarding potential directions for future research is presented.

Demographics

Individuals with schizophrenia generally show lower verbal IQs than the general population (Aylward, Walker, & Bettes, 1984). This was also the case in this study, but their verbal IQs were significantly different in comparison to the relative groups only, not to the control groups.

Overall, there was an equal number of male and female participants. However, there was a preponderance of females in the psychiatric control group as well as the schizotypal relative group, and there was a preponderance of males in the schizophrenia group as well as the nonpsychiatric control group.

The individuals with schizophrenia in this study were rarely married, received only high school education, and were mostly unemployed. Only 50% of the schizotypal relatives were married. Similar to the individuals with schizophrenia, the majority of schizotypal relatives (70%) in this study received only high school education, 25% were unemployed, and fewer of them were

classified as professionals than in the other groups. In contrast, 80% of the nonschizotypal group were married and 50% had post secondary education. In addition, the nonschizotypal group generally worked in more cognitively demanding jobs.

In summary, the demographic variables reported reveal that the schizophrenia participants in this study had lower verbal IQs (although not significantly lower than the two control groups), were rarely married, received low levels of education, and were generally unemployed. These variables demonstrate the profound negative effects experienced by individuals with schizophrenia. The present demographic findings support the work of researchers who have demonstrated that individuals with schizophrenia have a profoundly lowered quality of life compared to others (Gupta, Kulhara, & Verma, 1998; Priebe, Warner, Hubschmid, & Eckle, 1998). The next section discusses the findings from the memory scanning tasks, which are suggestive that this area is also negatively impacted by schizophrenia.

Memory Scanning

Sternberg's (1969a) paradigm was utilized to examine memory scanning in the groups employed in the present study. Sternberg's contribution lies in the discovery that set-size influences scanning rate and that the nature of scanning is serial and exhaustive as indicated by equivalent scanning rates (slope) for positive and negative trials.

Scanning rates. The data obtained by the present study revealed that the schizophrenia group demonstrated significantly slower scanning rates. The data also suggest that for some of the conditions, the schizotypal relatives and their schizophrenia probands had greater homogeneity than was found among

nonschizotypal relatives and their schizophrenia probands. This study also showed that the participants used a self-terminating search strategy, instead of the predicted serial exhaustive search.

More specifically, the schizophrenia participants demonstrated the slowest scanning rate of all the groups for Verbal stimuli. They also demonstrated the slowest scanning rates for accurate No responses. Examination of the data revealed that their scanning rate for Verbal No responses was very slow (82.25 ms). The results indicate that, as a group, individuals with schizophrenia scan items held in short-term memory (STM) much more slowly than other participants in the study. Similar slow scanning rates have been reported in studies with individuals with mental retardation (Mosley, 1985), Parkinson's disease (Laflèche, Stuss, Nelson, & Picton, 1990), learning disabilities (Elbert, 1984), developmental language disorders (Klatzky & Atkinson, 1970), and aphasia (Swinney & Taylor, 1971).

A relationship between intelligence and speed of memory scanning has been observed by many researchers (e.g., Necka, 1992; Neubauer & Knorr, 1998; Neubauer, Riemann, Mayer, & Angleitner, 1997). Usually, fast memory scanning rates are associated with higher intelligence. Findings from the current study support the relationship between intelligence and scanning speed. For example, the individuals with schizophrenia demonstrated the slowest scanning rate and had the lowest verbal IQ, although their verbal IQs were comparable to the two control groups. However, this study did not assess performance IQs and it has been demonstrated that performance IQs of schizophrenia patients are significantly lower than their verbal IQs (Aylward, Walker, & Bettes, 1984;

Goldberg, Karson, Leleszi, & Weinberger, 1988; Purcell, Lewine, Caudle, & Price, 1998).

Slow memory scanning rates have been thought to contribute to differences in length of memory span (Puckett & Kausler, 1984). Memory span tasks involve the presentation of increasingly longer lists of items, with the longest to achieve a certain error criterion in ordered recall being reported as the span. The span, therefore, can be considered a measure of the storage capacity of short-term memory. Cavanagh (1972) originally found, in a meta-analysis of approximately 30 studies, that a direct relationship was evident between memory span and memory search rates: the greater the memory span, the faster the scanning rate. Studies using individuals with schizophrenia consistently report deficits in memory span and these deficits are stable across clinical states (Asarnow & MacCrimmon, 1981; Asarnow, Nuechterlein & Marder, 1984; Nuechterlein et al., 1992; Stranburg, Marsh, Brown, Asarnow, & Guthrie, 1994). Coincidentally, the individuals with schizophrenia in this study had slow scanning rates which is consistent with the poor memory spans demonstrated by schizophrenia patients in general.

A decrement in attentional resources is another factor related to the difficulty experienced by schizophrenia patients. In the memory scanning paradigm, controlled (Shiffrin & Schneider, 1977), effortful processing (Hasher & Zacks, 1979) appears to be a requisite to scanning. According to Goldberg, Weinberger, Berman, Pliskin, and Plodd (1987) schizophrenia is characterized by problems with cognitive tasks of an unfamiliar sort (e.g., Chinese characters, which by their nature require attentional resources), and by difficulties in learning (because controlled processes are essential to learning). The memory

scanning paradigm fits these criteria in that the unfamiliar stimuli require the ability to abstract, sequence, switch mental sets, and use working memory. It appears to require effortful processing which is deficient in schizophrenia (Nuechterlein, 1991) as demonstrated by the significantly poorer performance for the nonverbal (Chinese characters) "No" condition.

Given the connection of slow memory scanning rates, low memory span and inefficient attentional resources, it is possible to identify the "anomalous" components of the information processing system of schizophrenia patients using, for example, Cowan's (1988) model which has already been discussed. For example, one possibility is that the initial brief sensory storage is not functioning correctly, so that the stimulus coding is slow, resulting in slow scanning rates.

Another prominent possibility is that central executive control of voluntary attention is inefficient, leading to either failure to place appropriate stimuli in the focus of attention or a failure to enhance the processing of the selected stimuli resulting in inefficient, slow scanning rates.

Although it is not possible at present to provide a clear answer to the question of whether "anomalous" memory scanning rates involve just one or a specific combination of information processing components, it is clear that the paradigm has promise for studies in cognitive deficits in schizophrenia.

Memory scanning intraclass correlations. Intraclass Correlation Coefficients were used to investigate the variability of scanning rate (slope) among schizotypal relatives and their schizophrenia probands and among nonschizotypal relatives and their schizophrenia probands. Greater homogeneity was found among schizotypal relatives and their schizophrenia probands than among nonschizotypal relatives and their probands in the Verbal

Yes (.47 vs. .10) and Nonverbal No (.62 vs. .22) conditions. Although these findings suggest a close relationship between schizotypal first-degree relatives and their schizophrenia probands, the findings from the other conditions (Verbal No and Nonverbal Yes) are not supportive.

The Verbal Yes and Nonverbal No ICCs are consistent with the many neurocognitive deficits that are detected in schizophrenia and also observed in their first-degree relatives, particularly if those relatives are schizotypal (Keefe et al., 1997; Steinhauer et al., 1991). An explanation for the increased likeness between schizotypal first-degree relatives and their schizophrenia probands may revolve around the two groups' genetic similarities (Baron, 1987; Kendler et al., 1984). Since schizotypal relatives share genes with their schizophrenia probands they would be expected to manifest similar cognitive deficits, but to a lesser degree (Mednick & Schulsinger, 1965; Weintraub, 1987). For example, the Span of Apprehension task (SPAN), backward visual masking, and the Continuous Performance Test (CPT), have revealed consistent cognitive performance deficits for schizophrenia patients across clinical states, among family members of schizophrenia patients, and with schizotypal individuals and therefore, are suggested as vulnerability markers (cf. Nuechterlein, Dawson, & Green, 1994). Nonschizotypal relatives and their probands also share genes, but according to the vulnerability/stress model (Mirsky and Duncan, 1986) these individuals may not have experienced the required stress to move them into a schizophrenia spectrum disorder (e.g., SPD).

Nature of memory scanning. Overall responses to the positive probes were faster than the responses to the negative probes. According to the serial exhaustive scanning theory, this discrepancy was not anticipated and not

indicative of the expected serial exhaustive search strategy. The memory scanning rate (slope) values for positive and negative responses should be similar to indicate exhaustiveness of the search. Sternberg (1975) suggested that the ratio between positive and negative trials for a self-terminating search is expected to be approximately 1:2. For an exhaustive search, the ratio is expected theoretically to be 1:1. In this study, the scanning rate ratio for verbal stimuli was 1:1.75 and for nonverbal stimuli the slope ratio was 1:1.91. Therefore, data from this study support a self-terminating search strategy. Appendix W summarizes the ratios of positive and negative trials for each group.

Support for a self-terminating search strategy has been reported in the literature. For example, Ashby, Tein, and Balakrishnan (1993), Eriksen, Eriksen, and Hoffman (1986), Kristofferson (1972), and Williams, Cooper, and Hunter (1990) have found significant scanning rate differences between negative (no) and positive (yes) trials in the general population. Similarly, Mosley (1985) reported comparable findings with mentally retarded individuals.

Memory Scanning Conclusions

The memory scanning task used in this study detected atypical scanning rates in participants with schizophrenia but did not reveal consistent differences between schizotypal relatives and nonschizotypal relatives. Although evidence from this study suggests that schizotypal relatives are more similar to the schizophrenia probands than nonschizotypal relatives, it is not unequivocal. However, since the memory scanning task was sensitive to participants with schizophrenia and the ICCs revealed some differences between schizotypal relatives and nonschizotypal relatives, memory scanning rate should not be ruled out as a potential marker for a predisposition to schizophrenia.

The results from the memory scanning rate (slope) analyses are not consistent with Sternberg's (1966, 1969a) serial exhaustive memory scanning view since the set-size comparisons are significantly greater for negative (no) trials. The scanning rate differential between negative and positive trials has been suggested to be impossible to reconcile with the serial exhaustive search model (Townsend & Zandt, 1990) and is more consistent with a self-terminating search strategy.

Hemispheric Lateralization

The results of this study in the area of hemispheric lateralization indicate that the schizophrenia patients demonstrated typical lateralization in both dichotic and dichoptic tasks. The main significant finding was in dichotic listening, where both relative groups revealed lower accuracy for right ear (left hemisphere) responses in comparison to the other groups. This study also showed that a greater amount of homogeneity was found among schizotypal first-degree relatives and their schizophrenia probands than among nonschizotypal first-degree relatives and their schizophrenia probands.

Dichotic Listening Task

In examining the hemispheric lateralization data for the participants in this study (including the "different" condition), only the dichotic verbal task, utilizing consonant vowels (CVs) as stimuli revealed meaningful group differences. When CVs were used as stimuli in this study, the expected right ear advantage (REA) was demonstrated (accuracy) by the schizophrenia group ($\underline{M}$ = 71.46%), the psychiatric control group ($\underline{M}$ = 80.42%), and the nonpsychiatric control group ($\underline{M}$ = 73.60%). The present findings support prior work in the area of schizophrenia and dichotic listening. In particular, these findings corroborate

work completed by Johnson and Crockett (1982) and Wexler, Giler, and Southwick (1991) who suggested that stabilized individuals with schizophrenia demonstrate expected REA for dichotic CV tasks. However, Green, Hugdahl, and Mitchell (1994) discovered that atypical laterality patterns emerge when schizophrenia patients are hallucinating and therefore emphasized that clinical state is a major factor in influencing abnormal lateralization. The schizophrenia patients in this study were stabilized and had the expected typical lateralization.

Although the dichotic verbal CV task used in this study revealed the expected REA with the schizophrenia group, this was not the case for the first-degree relative groups. The results of the dichotic listening task revealed a different pattern of auditory lateralization when CVs were used as stimuli for both the nonschizotypal and schizotypal relative groups. A left ear advantage (LEA) (accuracy) on the dichotic CV task was detected in the nonschizotypal relative group (right ear M = 49.95%, left ear M = 75.16%) and the schizotypal relative group (right ear M = 50%, left ear M = 69.3%). The LEA was the result of significantly lower than expected accuracy for right ear CV targets (see Figure 4.4, Chapter IV).

The findings from this study's auditory lateralization task using CV stimuli are consistent with lateralization studies where normal individuals were separated into high and low scoring groups (median-split) on the Schizotypal Personality Scale (SPS). For example, Broks, Claridge, Matheson, and Hargreaves (1984) used a dichotic task to assess hemispheric lateralization for verbal stimuli and found that high scoring individuals on the SPS demonstrated a LEA. Similarly, Rawlings and Borge (1987) also used a dichotic task to assess hemispheric lateralization for verbal processing and found an absence of the

expected REA with individuals who scored high on the SPS. Based on previous research in SPD and hemispheric lateralization, the atypical lateralization demonstrated by the schizotypal relative group in this study is not surprising.

One finding that was not expected, was that the nonschizotypal relative group also demonstrated atypical lateralization. However, other family studies have found cognitive deficits in first-degree relatives of schizophrenia patients in the absence of a schizotypal/nonschizotypal distinction. For example, cognitive studies employing the SPAN, backward masking, and the CPT in schizophrenia patients and their first-degree relatives have reported anomalies in both patient and first-degree relative groups (cf. Nuechterlein, Dawson, & Green, 1994). Even though these tests did not employ a schizotypal/nonschizotypal distinction, they were able to uncover anomalies in a majority of first-degree relatives.

An explanation for atypical lateralization in first-degree relatives observed in this study, both schizotypal and nonschizotypal, is based on the vulnerability/stress models of schizophrenia. The major components of the vulnerability/stress model are usually viewed along a continuum, which begins with individuals who do not have a schizophrenia spectrum disorder but might be genetically predisposed to schizophrenia (e.g., nonschizotypal relatives), and proceeds to individuals with a spectrum disorder (e.g., SPD), and finally ends with schizophrenia itself. Mirsky and Duncan (1986) suggest that there is an inverse relationship between the extent of the genetic predisposition (vulnerability) and the amount of stress that is necessary to push someone across a "threshold," which starts with schizotypal personality disorder and continues into schizophrenia. With more vulnerability (predisposition to schizophrenia), less stress is needed to cross the threshold.

The results of this study indicate that atypical hemispheric lateralization can be considered a likely indicator of vulnerability to schizophrenia because atypical lateralization was found in first degree relatives of schizophrenia patients and because previous research has detected similar atypical lateralization in psychotic schizophrenia patients (Green et al., 1994). Accordingly, it appears that the nonschizotypal relatives have a genetic vulnerability to schizophrenia which is demonstrated by atypical lateralization. The schizotypal relatives demonstrate both atypical lateralization and the schizophrenia-like traits of schizotypal personality. These schizotypal relatives are either more vulnerable or have experienced more than sufficient stress necessary to move them across the threshold. The greater the vulnerability, the higher the risk for developing schizophrenia (Cromwell & Spaulding, 1978; Nuechterlein & Dawson, 1984; Zubin & Spring, 1977).

Dichotic listening intraclass correlations. The results from this study demonstrate that in most of the dichotic listening conditions, greater homogeneity for schizotypal relatives and their schizophrenia probands was revealed in comparison to nonschizotypal relatives and their schizophrenia probands. This is in contrast to the greater homogeneity found among nonschizotypal relatives and their schizophrenia probands in most dichoptic viewing conditions.

Intraclass correlations group means revealed that schizotypal relatives and their probands had poorer performances in all dichotic listening conditions in comparison to nonschizotypal relatives and their probands. For the dichoptic viewing conditions, intraclass correlations group means revealed that schizotypal relatives and their probands had poorer performances in only half of

the dichotic listening conditions in comparison to nonschizotypal relatives and their probands. For the other half of the dichoptic conditions, they had comparable or better performances relative to the nonschizotypal group and their probands.

The findings from the dichotic listening ICCs provide evidence that schizotypal relatives and their schizophrenia probands were more alike than the nonschizotypal relatives and their probands in the auditory modality with the opposite being true for the dichoptic viewing task (visual modality). This suggests that both schizotypal and nonschizotypal first-degree relatives have a vulnerability to schizophrenia because their performances were similar to their probands and that atypical lateralization can be a cognitive marker of a predisposition for schizophrenia.

Hemispheric Lateralization Conclusions

This study showed that a majority of the participant groups were typically lateralized for the dichotic and dichoptic tasks. From the main ANOVAs, the schizophrenia group demonstrated typical lateralization. This is usually found when they are stabilized and on medication (Green, Hugdahl, & Mitchell, 1994). Green and colleagues (1994) concluded that schizophrenia patients who are not stabilized usually demonstrate an atypical performance and that this deviation be considered as a symptom-linked vulnerability marker.

The ANOVA also revealed atypical hemispheric lateralization (LEA) for both groups of first-degree relatives. This LEA has also been found in schizotypal individuals in nonclinical samples (Broks et al., 1984; Rawlings & Borge, 1987). However, atypical hemispheric lateralization in nonschizotypal first-degree relatives was not expected. This anomaly may be evidence of a

cognitive marker for vulnerability because it was found in family members with schizophrenia patients.

The results from the dichotic listening ICCs revealed that the schizotypal relatives and their schizophrenia probands had greater homogeneity than was found between the nonschizotypal relatives and their schizophrenia probands. The homogeneity was due to the schizotypal relatives and the schizophrenia probands consistently poor performances. Since schizotypal individuals are reported to have a predisposition to schizophrenia (Baron, Gruen, Anis, & Kane, 1983; Grove, Lebow, Clementz, Cerri, Medus, & Iacono, 1991; Kendler, Masterson, Ungaro, & Davis, 1984) one would expect them to demonstrate the cognitive deficits found in schizophrenia, but to a lesser degree. The nonschizotypal relatives and their schizophrenia probands demonstrated greater homogeneity for the dichoptic viewing task; however, their performances were not consistently better or poorer in comparison to the schizotypal relatives and their probands in the auditory task.

In conclusion, the hemispheric lateralization results from this study document the presence of an atypical auditory hemispheric lateralization in the first-degree relatives of individuals with schizophrenia. In addition, the schizotypal relatives are more like their schizophrenia probands than the nonschizotypal relatives and their probands in the auditory modality. This pattern of laterality, if shown to be reliably present, could function as a marker for a vulnerability to schizophrenia.

General Discussion

The aim of this research was to determine whether the information processing deficits found in individuals with schizophrenia also exist, to some degree, in their first-degree relatives. The findings of this research established that first-degree relatives of schizophrenia patients, especially schizotypal relatives, manifested some of the cognitive deficits reported for individuals with schizophrenia. These findings, aside from underscoring the familial nature of cognitive deficits in schizophrenia, might help explain some of the clinical psychopathology often found in the relatives of individuals with schizophrenia, i.e., disorganized thinking and perceptual aberrations.

Memory scanning reveals performance deficits in individuals with schizophrenia and additionally, it detects greater similarities among schizotypal relatives and their schizophrenia probands in some of the conditions than among nonschizotypal relatives and their probands. Although this is the first study to assess memory scanning in first-degree relatives using Sternberg's paradigm, parallel findings from a similar field of research (Span of Apprehension) have been reported (Asarnow, Granholm, & Sherman, 1991; Asarnow, Nuechterlein, & Marder, 1983). Findings from the current study underscore the familial nature of memory scanning deficits in schizophrenia. Since this task was sensitive to individuals with schizophrenia in a stabilized state and also detected a likeness between schizotypal relatives and their probands, it should be considered as a possible cognitive marker for a vulnerability to schizophrenia.

Stabilized schizophrenia patients demonstrated normal lateralization on the dichotic CV task and this has also been found in other studies (i.e., Johnson & Crockett, 1982; Wexler, Giler, & Southwick, 1991). In contrast, researchers have

reported that the dichotic CV task reveals atypical hemispheric lateralization in schizophrenia patients who were experiencing a psychotic episode (Green et al., 1991). In reference to first-degree relatives of individuals who have schizophrenia, the dichotic CV task has revealed atypical lateralization. Although this is the first study to assess hemispheric lateralization among first-degree relatives using the dichotic CVs, other studies using similar stimuli found comparable results (Broks et al., 1984; Rawlings & Borge, 1987). The present findings underscore the familial nature of atypical hemispheric asymmetries, specifically in the auditory modality. Since atypical asymmetries detected by the dichotic CV task appear to be state dependant (detectable during psychotic episodes but not in a stabilized condition) and are present to a greater degree in first-degree relatives than in the general public, they can be considered as a cognitive marker for a vulnerability to schizophrenia. Support for this position came from the ICCs for the dichotic CV task. In this task greater similarities (slower RTs and lower accuracy rates) between schizotypal relatives and their schizophrenia probands were revealed in comparison to the nonschizotypal relatives and their probands in all dichotic conditions. The next section discusses the advantages and limitations of this study and is followed by the final section, which suggests directions for future research.

Advantages and Limitations

One of the limitations of this study was the inability to assess cognition in both genders. For example, the schizophrenia and nonpsychiatric control groups were comprised of 75% males, whereas the psychiatric control and schizotypal groups were comprised of 75% females. The nonschizotypal relative group was balanced. Gender differences in hemispheric lateralization has been reported in

prior research. Bryden (1992) observed that lateralized function (mean magnitude of asymmetry) is more pronounced in males relative to females.

The present study employed the Schizotypal Personality Scale (SPS). Use of the SPS is considered a strength by some authors in the field (e.g., Claridge & Hewitt, 1987). First-degree relatives were assessed with the SPS, then separated into a schizotypal group or a nonschizotypal group based on a median split. Although the median split method is commonly used, the method has been criticized in the past. The main concern revolves around the possible clustering of scores at the median. If participants are dichotomously separated by only 1 or 2 points, the method might not adequately assess true differences between groups, especially if many participants are clustered around the median.

An important limitation of this study addresses the issue of clinical state. The stabilized schizophrenia patients in this study manifested typical lateralization patterns whereas the first-degree relatives did not. Inclusion of a group of hallucinating schizophrenia patients would have allowed the researcher to contrast the lateralization patterns with nonhallucinating, stabilized patients and the first-degree relative groups. Without such a group, the study was reliant on prior research which suggested that hallucinating schizophrenia patients manifested atypical lateralization patterns, similar to that reported for the first-degree relatives in this study.

The final limitation in this study was the inability to differentiate between paranoid and nonparanoid subtypes of schizophrenia. Magaro and Chamrad (1983a) have found differences between paranoid and nonparanoid schizophrenia patients on dichoptic viewing tasks. However, the patient

population in this study was comprised of predominantly paranoid schizophrenia patients and therefore, findings are limited to this subtype only.

One of this study's strengths was the minimal task demand placed upon the participants. The specific stimuli were selected because they provided a way of minimizing the influence of memory load and attentional bias which has been proposed as an important stimulus factor (Yeni-Komshian & Gordon, 1974). For example, great efforts were made to minimize the influence of factors which could confound dichotic listening CV data. This study addressed the influence of stimulus dominance resulting in only four usable pairs of CVs (pa-ta, pa-ka, ta-ga, and ba-da). Stimulus dominance arises when a significantly higher detection occurs for one of the competing CV syllables in a pair regardless of the ear to which that syllable is presented. Studies which have not considered stimulus dominance can be challenged from a methodological point of view (Speaks, Carney, Niccum, & Johnson, 1981).

The use of VScope™, a software program developed by Resnick and Enns (1992), controlled stimuli sequencing and tachistoscopic exposure intervals. The VScope™ program also collected and stored subject response data. This afforded the researcher a greater degree of precision in the timing of stimulus presentations and participant responses.

Uncovering potential memory scanning deficits and atypical hemispheric lateralization that may be linked to a vulnerability to schizophrenia is a significant contribution to the existing literature in the field. If the two tasks reliably reveal cognitive deficits in individuals with schizophrenia and their first-degree relatives (especially schizotypal first-degree relatives) they would be able to differentiate those at risk from those who are not at risk for developing

schizophrenia. By screening individuals at risk for schizophrenia, early detection of a predisposition would be possible, and ultimately result in earlier preventative interventions.

Directions for Future Research

Future studies need to determine whether memory scanning inefficiencies are present during the longitudinal course of schizophrenia as well as during different clinical states. If slower scanning rates are found to be present throughout the longitudinal course of schizophrenia and across clinical states, this would confirm that slow scanning rates are an enduring cognitive marker for a vulnerability to schizophrenia.

Future studies should also determine if altering stimuli (e.g., increasing memory load or adding a perceptual burden) would produce significantly different scanning rates with first-degree relatives as has been observed with the CPT (Keefe, et al., 1997; Steinhauer et al., 1991). Further, such alterations with the memory scanning task may serve to distinguish schizotypal from nonschizotypal first-degree relatives.

The results of the present study have uncovered an atypical lateralization pattern for first-degree relatives on the dichotic listening task. This finding should be replicated to ensure that these are not just spurious findings.

Future studies should also determine if changing the method of determining schizotypal and nonschizotypal relatives (e.g., using 1st and 4th quartile scores of the SPS vs. split median) would produce significantly different results.

Finally, the clinical utility of this work needs to be extended. The question as to whether cognitive remediation is effective and what specific areas of the

schizophrenia patients' life are being enhanced as a result of remediation must be addressed. For example, correlations between cognitive function, clinical symptoms, social functioning, and prognosis need to be examined in order to ensure that appropriate interventions are taking place.

References

Aharonovich, E., Karny, N., & Nachson, I. (1993). Visual field processing in paranoid and nonparanoid schizophrenics. *European Psychiatry, 8,* 301-307.

Alpert, M., Rubinstein, H., & Kesselman, M. (1976). Asymmetry of information processing in hallucinating and nonhallucinating schizophrenics. *Journal of Nervous and Mental Disease, 162,* 258-265.

American Psychiatric Association. (1968). *Diagnostic and statistical manual of mental disorders* (DSM-II). Washington, DC: American Psychiatric Association.

American Psychiatric Association. (1980). *Diagnostic and statistical manual of mental disorders* (DSM-III). Washington, DC: American Psychiatric Association.

American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders* (DSM-III-R). Washington, DC: American Psychiatric Association.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (DSM-IV). Washington, DC: American Psychiatric Association.

Anders, T. R., Fozard, J. L., & Lillquist, T. D. (1972). Effects of age upon retrieval from short-term memory. *Developmental Psychology, 6,* 214-217.

Andreasen, N. C., Arndt, S., Swayze II, V., Cizadlo, T., Flaum, M. O'Leary, D., Ehrhardt, J. C., & Yuh, W. T. C. (1994). Thalamic abnormalities in

schizophrenia visualized through magnetic resonance image averaging. *Science, 266,* 294-298.

Andreasen, N. C., & Carpenter, W. T. (1993). Diagnosis and classification of schizophrenia. *Schizophrenia Bulletin, 19,* 199-214.

Andreasen, N. C., & Flaum, M. (1991). Schizophrenia: The characteristic symptoms. *Schizophrenia Bulletin, 17,* 27-49.

Arnold, S. E., Hyman, B. T., VanHoesen, G. W., & Damasio, A.R. (1991). Some cytoarchitectural abnormalities of the enthorhinal cortex in schizophrenia. *Archives of General Psychiatry, 48,* 624-632.

Asarnow, R. F., Granholm, E., & Sherman, T. (1991). Span of apprehension in schizophrenia. In S. R. Steinhauer, J. H. Gruzelier, & J. Zubin (Eds.), *Handbook on schizophrenia: Neuropsychology, psychophysiology, and information processing* (Vol. 5). Amsterdam: Elsevier.

Asarnow, R. F., & MacCrimmon, D. J. (1978). Residual performance deficit in clinically remitted schizophrenics: A marker of schizophrenia? *Journal of Abnormal Psychology, 87,* 597-608.

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

Asarnow, R. F., & MacCrimmon, D. J. (1982). Attention/information processing, neuropsychological functioning and thought disorder during the acute and partial recovery phases of schizophrenia: A longitudinal study. *Journal of Psychiatric Research, 7,* 309-319.

Asarnow, R. F., Marder, S. R., Mintz, J., Van Putten, T., & Zimmerman, K. E. (1988). The differential effect of low and conventional doses of

fluphenazine deconoate on schizophrenic outpatients with good or poor information processing abilities. *Archives of General Psychiatry, 45,* 822-886.

Asarnow, R. F., Nuechterlein, K. H., & Marder, S. R. (1983). Span of apprehension performance, neuropsychological functioning, and indices of psychosis-proneness. *The Journal of Nervous and Mental Disease, 171,* 662-669.

Asarnow, R. F., Nuechterlein, K. H., Torquato, R., Subotnik, K., & Folgelson, D. (1997). Cognitive/neuropsychological abnormalities in the parents of children with a schizophrenic disorder. *Schizophrenia Bulletin, 24* (abstract), 45.

Asarnow, R. F., & Sherman, T. (1984). Studies of visual information processing in schizophrenic children. *Child Development, 55,* 249.

Asarnow, R. F., Steffy, R. A., Cleghorn, J. M., & MacCrimmon, D. J. (1979). The McMaster-Waterloo studies of children at risk for severe psychopathology. In J. Shamsie (Ed.), *New directions in children's mental health.* New York: Spectrum Publications.

Asarnow, R. F., Steffy, R. A., MacCrimmon, D. J., & Cleghorn, J. M. (1977). An attentional assessment of foster children at risk for schizophrenia. *Journal of Abnormal Psychology, 86,* 267-275.

Aschauer, H. N., Aschauer-Treiber, G., Isenberg, K. E., Todd, R. D., Knesevich, M. A., Garver, D. L., Reich, T., & Cloninger, C. R. (1990). No evidence for linkage between chromosome 5 markers and schizophrenia. *Human Heredity, 40,* 109-115.

Ashby, F. G., Tein, J., & Balakrishnan, J. D. (1993). Response time distributions in memory scanning. *Journal of Mathematical Psychology, 37,* 526-555.

Aylward, E., Walker, E., & Bettes, B. (1984). Intelligence in schizophrenia: Meta-analysis of the research. *Schizophrenia Bulletin, 10,* 430-459.

Balogh, D. W., & Merritt, R. D. (1985). Susceptibility to type A backward pattern masking among hypothetically psychosis-prone college students. *Journal of Abnormal Psychology, 94,* 377-383.

Balogh, D. W., Merritt, R. D., Lennginton, L., & Fine M. (1993). Variants of the MMPI 2-7-8 code type: Schizotypal correlates of high point 2, 7, or 8. *Journal of Personality Assessment, 61,* 474-488.

Baron, M. (1987). Genetic models and the transmission of schizophrenia. In H. Hafner, W. F. Gattaz & Janzarik (Eds.), *Search for the causes of schizophrenia.* Berlin: Springer.

Baron, M., Gruen, R., Asnis, L., & Kane, J. (1983). Familial relatedness of schizophrenia and schizotypal states. *American Journal of Psychiatry, 140,* 1437-1442.

Baron, M., Gruen, R., Rainer, J. D., Kane, J., Asnis, L., & Lord, S. (1985). A family study of schizophrenic and normal control probands: Implications for the spectrum concept of schizophrenia. *American Journal of Psychiatry, 142,* 447-455.

Barr, C. E., Mednick, S. A., & Munck-Jorgenson, P. (1990). Maternal influenza and schizophrenic births. *Archives of General Psychiatry, 47,* 869-874.

Bassett, A. S., Jones, B. D., McGillivray, B. C., & Pantzar, J. T. (1988). Partial trisomy chromosome 5 cosegregation with schizophrenia. *Lancet, 1,* 799-800.

Battaglia, M., Gasperini, M., Sciuto, G., Scherillo, P., Diaferia, G., & Bellodi, L. (1991). Psychiatric disorders in the families of schizotypal subjects. *Schizophrenia Bulletin, 17,* 659-668.

Beaton, A. (1986). *A review of laterality research.* London: Yale University Press.

Beaumont, J. G., & Dimond, S. J. (1973). Brain disconnection and schizophrenia. *British Journal of Psychiatry, 123,* 661-662.

Beech, A. & Claridge, G. (1987). Individual differences in negative priming: Relations with schizotypal personality traits. *British Journal of Psychology, 78,* 349-356.

Benes, F. M., Davidson, J., & Bird, E. D. (1986). Quantitative cytoarchitectural studies of the cerebral cortex of schizophrenics. *Archives of General Psychiatry, 43,* 31-35.

Benson, D. F., & Zaidal, E. (1985). *The dual brain.* New York: Guilford Press.

Bergman, A. J., Harvey, P. D., Roitman, S. L., Mohs, R. C., Marder, D., Silverman, J. M., & Siever, L. J. (1998). Verbal learning and memory in schizotypal personality disorder. *Schizophrenia Bulletin, 24,* 635-641.

Berlin, C. I., & McNeil, M. R. (1976). Dichotic listening. In N. J. Lass (Ed.), *Contemporary Issues in Experimental Phonetics,* New York: Academic Press.

Billings, L. S., Harrison, D. W., & Alden, J. D. (1993). Age differences among women in the functional asymmetry for bias in facial affect perception. *Bulletin of the Psychonomic Society, 31,* 317-320.

Bleuler, E. (1950). *Dementia praecox or the group of schizophrenias* (J. Zinkan, Trans.). New York: International University Press. (Original work published in 1911).

Boyer, R. W., & Charleston, D. E. (1985). Auditory memory search. *Perceptual and Motor Skills, 60,* 927-939.

Bracha, H. S., Torrey, E. F., Bigelow, L. B., Lohr, J. B., & Linington, B. B. (1991). Subtle signs of prenatal maldevelopment of the hand ectoderm in schizophrenia: A preliminary monozygotic twin study. *Biological Psychiatry, 30,* 719-725.

Bracha, H. S., Torrey, E. F., Gottesman, I. I., Bigelow, L. B., & Cunniff, C. (1992). Second-trimester markers of fetal size in schizophrenia: A study of monozygotic twins. *American Journal of Psychiatry, 149,* 1355-1361.

Braff, D. L. (1981). Impaired speed of information processing in non-medicated schizotypal patients. *Schizophrenia Bulletin, 7,* 449-508.

Braff, D. L., Heaton, R., & Kuck, J. (1991). The generalized pattern of neuropsychological deficits in outpatients with chronic schizophrenia with heterogeneous Wisconsin Card Sorting results. *Archives of General Psychiatry, 48,* 891-898.

Braff, D. L., Saccuzzo, D. P., & Geyer, M. A. (1991). Information processing dysfunctions in schizophrenia: Studies of visual backward masking, sensorimotor gating, and habituation. In S. R. Steinhauer, J. H. Gruzelier, & J. Zubin (Eds.), *Handbook of schizophrenia,* Vol. 5. Amsterdam: Elsevier.

Breitmeyer, B. G. (1984). *Visual masking: An integrative approach.* New York: Oxford University Press.

Breitmeyer, B. G., & Ganz, L. (1976). Implications of sustained and transient channels for theories of visual pattern masking, saccadic suppression, and information processing. *Psychological Review, 83,* 1-36.

Broks, P. (1984). Schizotypy and hemisphere function: II. Performance asymmetry for a verbal disordered visual task. *Personality and Individual Differences, 5,* 649-656.

Broks, P., Claridge, G., Matheson, J., & Hargreaves, J. (1984). Schizotypy and hemisphere function: IV. Story comprehension under binaural and monaural listening conditions. *Personality and Individual Differences, 5,* 665-670.

Bruder, G. E. (1983). Cerebral laterality and psychopathology: A review of dichotic listening studies. *Schizophrenia Bulletin, 9,* 134-151.

Bruder, G. E., Rabinowicz, E., Towey, J., & Brown, A. (1995). Smaller right ear (left hemisphere) advantage for dichotic fused words in patients with schizophrenia. *American Journal of Psychiatry, 152,* 932-935.

Bull, H. C., & Venables, P. H. (1974). Speech perception in schizophrenia. *British Journal of Psychiatry, 125,* 350.

Cannon, M., Byrne, M., Cassidy, B., Larkin, C., Horgan, R., Sheppard, M. P., & O'Callaghan, E. (1995). Prevalence and correlates of mixed-handedness in schizophrenia. *Psychiatry Research, 59,* 119-125.

Carr, V., Wale, J., Dewis, S., & Stephan, L. (1992). The effects of illness duration on perceptual asymmetry in schizophrenia. *Schizophrenia Research, 7,* 211-216.

Carter, C. L., & Chung, C. S. (1980). Segregating analysis of schizophrenia under a mixed genetic model. *Human Heredity, 30,* 350.

Carter, C. S., Robertson, L. C., Nordahl, T. E., Chaderjian, M., & Oshora-Celaya, L. (1996). Perceptual and attentional asymmetries in schizophrenia:

further evidence for a left hemisphere deficit. *Psychiatry Research, 62,* 111-119.

Castle, D., & Murray, R. (1991). The neurodevelopmental basis of sex differences in schizophrenia. *Psychological Medicine, 21,* 565-575.

Cavanagh, P. J. (1972). Relation between the immediate memory span and the memory search rate. *Psychological Review, 79,* 525-530.

Claridge, G., & Broks, P. (1984). Schizotypy and hemisphere function: I. Theoretical considerations and the measurement of schizotypy. *Personality and Individual Differences, 5,* 633-648.

Clemenzt, B. A., Iacono, W. G., & Beiser, M. (1994). Handedness in first episode patients and their first degree biological relatives. *Journal of Abnormal Psychology, 103,* 400-403.

Clooney, J. L., & Murray, D. J. (1977). Same different judgements in paranoid and schizophrenic patients: A laterality study. *Journal of Abnormal Psychology, 86,* 655-658.

Cohen, N. J., & Squire, L. R. (1980). Preserved learning and retention of pattern analyzing skills in amnesia: Dissociation of knowing how and knowing that. *Science, 210,* 207-210.

Colbourne, C. J., & Lishman, W. A. (1979). Lateralization of function and psychotic illness: A left hemisphere deficit? In J. Gruzelier & P. Flor-Henry (Eds.), *Hemisphere asymmetries of function in psychopathology.* New York: Elsevier.

Connelly, J. F., Gruzelier, J. H., Kleinman, K. M., & Hirsch, S. R. (1979). Lateralized abnormalities in hemisphere specific tachistoscope tasks in

psychiatric patients and controls. In J. Gruzelier & P. Flor-Henry (Eds.), *Hemisphere asymmetries of function in psychology*. New York: Elsevier.

Conners, C. K., Casat, C. D., Gualtieri, C. T., & Weller, E. (1996). Bupropion hydrochloride in attention deficit disorder with hyperactivity. *Journal of the American Academy of Child and Adolescent Psychiatry, 35*, 1314-1321.

Conrad, A. J., & Scheibel, A. B. (1987). Schizophrenia and the hippocampus: The embryological hypothesis extended. *Schizophrenia Bulletin, 13*, 577-587.

Conrad, A. J., Abebe, T., Austin, R., Forsythe, S., & Scheibel, A. (1991). Hipocampal pyramidal cell disarray in schizophrenia as a bilateral phenomenon. *Archives of General Psychiatry, 48*, 413-417.

Coon, H., Holik, J., Hoff M., Reimer, F., Wender, P., Myles-Worsley, M., Waldo, M., Freedman, R., & Byerley, W. (1994). Analysis of chromosome 22 markers in 9 schizophrenia pedigrees. *American Journal of Medical Genetics, 54*, 72-79.

Corkin, S. (1968). Acquisition of motor skill after bilateral medial temporal-lobe excision. *Neuropsyologia, 6*, 255-265.

Cornblatt, B. A., Lenzenweger, M. F., Dworkin, R., & Erlenmeyer-Kimling, L. (1992). Childhood attentional dysfunction predicts social deficits in unaffected adults at risk for schizophrenia. *British Journal of Psychiatry, 161* (Suppl. 18), 59-64.

Cornblatt, B. A., Lenzenweger, M. F., & Erlenmeyer-Kimling, L. (1989). The continuous performance test, identical pairs version. II. Contrasting attentional profiles in schizophrenic and depressed patients. *Psychiatry Research, 29*, 65-85.

Cowan, N. (1998). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information-processing system. *Psychological Bulletin, 104,* 163-191.

Crow, T. J. (1990). Temporal lobe asymmetries as the key to the etiology of schizophrenia. *Schizophrenia Bulletin, 16,* 433-443.

David, A. S. (1993). Callosal transfer in schizophrenia: Too much or too little? *Journal of Abnormal Psychology, 102,* 573-579.

David, A. S., & Cutting, J. C. (1992). Categorical-semantic and dimensional-imagery judgements of non-verbal stimuli in the cerebral hemispheres. *Cortex, 28,* 39-51.

David, A. S., & Cutting, J. C. (1993). Visual imagery and visual semantics in the cerebral hemispheres in schizophrenia. *Schizophrenia Research, 8,* 263-271.

Dax, M. (1836). Lésions de la moité gauche de l'encéphale coincident avec l'oubli des signes de la pensée. *Gazette Hebdomadaire, 11,* 259-269.

DeRosa, D. V., Tkacz, S. (1976). Memory scanning of organized visual material. *Journal of Experimental Psychology: Human Learning and Memory, 2,* 688-694.

Detera-Wadleigh, S. D., Goldin, L. R., Sherrington, R., Encio, I., de Miguel, C., Berrettini, W., Gurling, H., & Gershon, E. S. (1989). Exclusion of linkage to 5q11-13 in families with schizophrenia and other psychiatric disorders. *Nature, 340,* 391-393.

Diehl, S., Su, Y., & Bray, J. (1991). Linkage studies of schizophrenia: Exclusion of candidate regions on chromosome 5q and 11q (abstract). *Psychiatric Genetics, 2,* 14-15.

Diener, D. (1988). Absence of the set-size effect in memory-search tasks in the absence of a preprobe delay. *Memory and Cognition, 16,* 367-376.

Eckblad, M., & Chapman, L. J. (1983). Magical ideation as an indicator of schizotypy. *Journal of Consulting and Clinical Psychology, 51,* 215-225.

Elbert, J. C. (1984). Short-term memory encoding and memory search in the word recognition of learning-disabled children. *Journal of Learning Disabilities, 17,* 342-345.

Eriksen, B. A., Eriksen, C. W., & Hoffman, J. E. (1986). Recognition memory and attentional selection: Serial scanning is not enough. *Journal of Experimental Psychology: Human Perception and Performance, 12,* 476-483.

Eriksen, C. W., Hamlin, R. M., & Daye, C. (1973). Aging adults and rate of memory scan. *Bulletin of the Psychonomic Society, 1,* 259-260.

Eysenck, H. J., & Eysenck, S. B. G. (1976). *Psychoticism as a dimension of personality.* New York: Crane, Russak.

Estes, W. K., & Taylor, H. A. (1964). A detection method and probabilistic models for assessing information processing from brief visual displays. *Proceedings of the National Academy of Science, U. S. A., 52,* 446-454.

Faraone, S. V., Seidman, L. J., Oscar-Berman, M., Kremen, W. S., Toomey, R., & Tsuang, M. T. (1997). Object alteration deficits in first-degree relatives of schizophrenic patients. *Schizophrenia Bulletin, 24* (abstract), 45.

Fennell, E. B., Moskowitz, R., & Backus, D. (1982). Dichotic listening in schizophrenic and depressed patients. Presented at International Neuropsychology Society Annual Meeting, Pittsburgh, PA.

Fish, B., Marcus, J., Hans, S. L., Auerbach, J. G., & Perdue, S. (1992). Infants at risk for schizophrenia. Sequelae of a genetic neurointegrative defect. *Archives of General Psychiatry, 49,* 221-235.

Flaum, M., & Schultz, S. K. (1996). The core symptoms of schizophrenia. *Annals of Medicine, 28,* 525-531.

Flaum, M., Swayze, V. W., O'Leary, D. S., Yuh, W. T. C., Ehrhart, J. C., Arndt, S. V., & Andreasen, N. C. (1995). Effects of diagnosis, laterality, and gender on brain morphology in schizophrenia. *American Journal of Psychiatry, 152,* 704-714.

Flor-Henry, P. (1969). Psychoses and temporal lobe epilepsy: A controlled investigation. *Epilepsia, 10,* 363-395.

Flor-Henry, P. (1976). Lateralized temporal-limbic dysfunction and psychopathology. *Annals of the New York Academy of Sciences, 280,* 777-797.

Flor-Henry, P. (1978). Gender, hemispheric specialization and psychopathology. *Social Science and Medicine, 128,* 155-162.

Flor-Henry, P. (1979). On certain aspects of the localization of the cerebral systems regulating and determining conditions. *Biological Psychiatry, 14,* 677-697.

Flor-Henry, P., & Yeudall, L. T. (1979). Neurological investigation of schizophrenia and manic depressive psychosis. In J. H. Gruzelier & P. Flor-Henry (Eds.), *Hemisphere asymmetries of function in psychopathology.* Amsterdam: Elsevier.

Fogliani, A. M., Parisi, R., Fogliani-Messing, T. M., & Rapisarda, V. (1985). Interhemispheric transfer of visual information in schizophrenics. *Perceptual Motor Skills,* 60, 867-870.

Frame, C. L., & Oltmanns, T. F. (1982). Serial recall by schizophrenic and affective patients during and after psychotic episodes. *Journal of Abnormal Psychology, 91,* 311-318.

Frangos, E., Athanassenas, G., Tsitourides, S. S., Katsanou, N., & Alexandrakou, P. (1985). Prevalence of DSM-III schizophrenia among the first degree relatives of schizophrenic probands. *Acta Psychiatrica Scandinavica, 72,* 382-386.

Gazzaniga, M. S. (1983). Fonctions cognitives de l'hémisphère gauche. *Revue de Neurologie, 139,* 19-22.

Gazzaniga, M. S. (1987). Perceptual and attentional processes following callosal sections in humans. *Neuropsychologia, 25,* 119-133.

Gershon, E. S., DeLisis, L. E., Hamivit, J., Nurnberger, J. I., Maxwell, M. E., Schreiber, J., Dauphinais, D., Dingman, C. W., & Guroff, J. J. (1988). A controlled family study of chronic psychoses: Schizophrenia and schizoaffective disorder. *Archives of General Psychiatry, 45,* 328-336.

Glass, A. L. (1984). Effect of memory set on reaction time. In R. J. Anderson & S. M. Kosslyn (Eds.), *Tutorials in learning and memory: Essays in honor of Gordon Bower.* San Francisco: Freeman.

Goldberg, T. E., & Gold, J. M. (1995). Neurocognitive functioning in patients with schizophrenia. In F. E. Bloom & D. J. Kupfer (Eds.), *Psychopharmacology: The fourth generation of progress.* New York: Raven Press.

Goldberg, T. E., Gold, J. M., Torrey, E. F., & Weinberger, D. R. (1995). Lack of sex difference in neuropsychological performance of patients with schizophrenia. *American Journal of Psychiatry, 152,* 883-888.

Goldberg, T. E., Karson, C. N., Leleszi, J. P., & Weinberger, D. R. (1988). Intellectual impairment in adolescent psychosis: A controlled psychometric study. *Schizophrenia Research, 1,* 261-266.

Goldberg, E., & Seidman, L. J. (1991). Higher cortical functions in normals and schizophrenics: A selective review. In S. R. Steinhaur, S. R. Gruzelier, & J. H. Zubin (Eds.), *Handbook of schizophrenia.* Amsterdam: Elsevier.

Goldberg, T. E., Weinberger, D. R., Berman, K. F., Pliskin, N. H., & Plodd, M. H. (1987). Further evidence for dementia of the prefrontal type in schizophrenia? A controlled study of teaching the Wisconsin Card Sorting Test. *Archives of General Psychiatry, 44,* 1008-1014.

Goldstein, J. M., Seidman, L. J., Santangelo, S., Knapp, P. H., & Tsuang, M. T. (1994). Are schizophrenic men at higher risk for developmental deficits than schizophrenic women? Implications for adult neuropsychological functions. *Journal of Psychiatric Research, 28,* 483-498.

Gottesman, I. I. (1991). *Schizophrenia Genesis.* New York: W. H. Freeman.

Gottesman, I. I., & Shields, J. (1982). *Schizophrenia, the epigenic puzzle.* New York: Cambridge University Press.

Granholm, E., Bartzokis, G., Asarnow, R. F., & Marder, S. R. (1993). Preliminary associations between motor procedural learning, basal ganglia T2 relaxation times, and tardive dyskinesia. *Psychiatry Research: Neuroimaging, 50,* 33-44.

Green, M. F. (1998). *Schizophrenia from a neurocognitive perspective.* Boston, MA: Allyn and Bacon.

Green, M. F., Bracha, S. H., Satz, P., & Christenson, C. (1994a). Preliminary evidence for an association between minor physical anomalies and second trimester neurodevelopment in schizophrenia. *Psychiatry Research, 53,* 119-127.

Green, M. F., Hugdahl, K., & Mitchel, S. (1994). Dichotic listening during auditory hallucinations in patients with schizophrenia. *American Journal of Psychiatry, 151,* 357-362.

Green, M. F., Nuechterlein, K. H., & Breitmeyer, B. (1997). Backward masking performance in unaffected siblings of schizophrenic patients. *Archives of General Psychiatry, 54,* 465-472.

Green, M. F., Nuechterlein, K. H., & Mintz, J. (1994a). Backward masking in schizophrenia and mania: Specifying a mechanism. *Archives of General Psychiatry, 51,* 939-944.

Green, M. F., Nuechterlein, K. H., & Mintz J. (1994b).). Backward masking in schizophrenia and mania: Specifying the visual channels. *Archives of General Psychiatry, 51,* 945-951.

Green, M. F., Satz, P., & Christenson, C. (1994b). Minor physical anomalies in schizophrenia patients, bipolar patients, and their siblings. *Schizophrenia Bulletin, 20,* 433-440.

Green, M. F., Satz, P., Gaier, D. J., Ganzell, S., & Kharabi, F. (1989a). Minor physical anomalies in schizophrenia. *Schizophrenia Bulletin, 15,* 91-99.

Green, M. F., Satz, P., Smith, C., & Nelson, L. (1989b). Is there atypical handedness in schizophrenia? *Journal of Abnormal Psychology, 98,* 57-61.

Green, M. F., & Walker, E. (1985). Neuropsychological performance and positive and negative symptoms in schizophrenia. *Journal of Abnormal Psychology, 94,* 460-469.

Greenberg, J. H., Reivich, M., & Alavi, A. (1981). Metabolic mapping of functional activity in human subjects with the (18F) - Fluorodeoxyglucose technique. *Science, 212,* 678-680.

Greene, R. L. (1992). *Human memory: Paradigms and paradoxes.* Hillsdale, NJ: Lawrence Erlbaum.

Grove, W. M., Lebow, B. S., Clementz, B. A., Cerri, Al, Medus, C., & Iacono, W. G. (1991). Familial prevalence and coaggregation of schizotypy indicators: A multitrait family study. *Journal of Abnormal Psychology, 100,* 115-121.

Gruzelier, J. H., and Flor-Henry, P. (Eds.) (1979). *Hemisphere asymmetries of function in psychopathology.* Amsterdam: Elsevier.

Gruzelier, J. H., & Hammond, N. V. (1980). Lateralized deficits and drug influences on the dichotic listening of schizophrenic patients. *Biological Psychiatry, 15,* 759-779.

Gruzelier, J., Seymour, K., Wilson, L., Jolley, A., & Hirsch, S. (1988). Impairments on neuropsychological tests of temporohippocampal and frontohippocampal functions and word fluency in remitting schizophrenia and affective disorders. *Archives of General Psychiatry, 45,* 623-629.

Guerrini, R., Dravet, C., Raybaud, C., & Rogers, J. (1992). Neurological findings and seizure outcomes in children with bilateral opercular macrogyric-like changes detected by MRI. *Developmental Medicine and Child Neurology, 34,* 694-705.

Gupta, S., Kulhara, P., & Verma, S. (1998). Quality of life in schizophrenia and dysthymia. *Acta Psychiatrica Scandinavica, 97,* 290-296.

Gur, R. E. (1978). Left hemisphere dysfunction and left hemisphere overactivation in schizophrenia. *Journal of Abnormal Psychology, 87,* 226-238.

Gur, R. E. (1979). Cognitive concomitants of hemisphere dysfunction in schizophrenia. *Archives of General Psychiatry, 36,* 269-274.

Gur, R E., Mozley, P. D., Resnick, S. M., Mozley, L. H., Shtasel, D. L., Gallacher, F., Arnold, S. E., Karp, J. S., Alavi, A., Reivich, M., & Gur, R. C. (1995). Resting cerebral glucose metabolism in first-episode and previously treated patients with schizophrenia relates to clinical features. *Archives of General Psychiatry, 52,* 657-667.

Gurling, H. M. (1992). *New microsatellite polymorphisms fail to confirm chromosome 5 linkage in Icelandic and British schizophrenia families.* Paper presented at the meeting of the American Psychopathological Association, New York.

Häfner, H., Hambrecht, M., Löffler, W., Munk-Jørgensen, P., & Riecher-Rössler, A. (1998). Is schizophrenia a disorder of all ages? A comparison of first episodes and early course across the life-cycle. *Psychological Medicine, 28,* 351-365.

Hallett, S., & Green, P. (1983). Possible defects of interhemispheric integration in children of schizophrenics. *Journal of Nervous and Mental Disease, 171,* 421-425.

Hallett, S., Quinn, D., & Hewitt, J. (1986). Defective interhemispheric integration and anomalous language lateralization in children at risk for schizophrenia. *Journal of Nervous and Mental Disease, 174,* 418-427.

Hallmayer, J., Maier, W., Ackenheil, M., Ertl, M. A., Schmidt, S., Minges, J., Lichtermann, D., & Wildenauer, D. (1992). Evidence against linkage of schizophrenia to chromosome 5q11-q13 markers in systematically ascertained families. *Biological Psychiatry, 31,* 83-94.

Harnad S., & Doty, R. W. (1977). Introductory overview. In S. Harnad, R. Doty, L. Goldstein, J. Jaynes, & G. Krauthamer (Eds.), *Lateralization in the nervous system.* New York: Academic Press.

Harris, A., Ayers, T., & Leek, M. R. (1985). Auditory span of apprehension deficits in schizophrenia. *Journal of Nervous and Mental Diseases, 173,* 650.

Harris, G. J., & Fleer, R. E. (1974). High speed mental scanning in retardates: Evidence for central processing deficit. *Journal of Experimental Child Psychology, 17,* 452-459.

Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General, 108,* 386-388.

Hatta, T., Ayetani, N., and Yoshizaki, K. (1984). Dichotic listening by chronic schizophrenic patients. *International Journal of Neuroscience, 23,* 75.

Hemsley, D. R. (1987). An experimental psychological model for schizophrenia. In H. Hafner, W. F. Gattaz, & A. Janzarik (Eds.), *Search for the causes of schizophrenia.* Heidelberg, Germany: Springer.

Heston, L. L. (1966). Psychiatric disorders in foster home reared children of schizophrenic mothers. *British Journal of Psychiatry, 112,* 819-825.

Hewitt, J. K., & Claridge, G. (1989). The factor structure of schizotypy in a normal population. *Personality and Individual Differences, 10,* 323-329.

Hillsburg, B. (1979). A comparison of visual discrimination performance of the dominant and nondominant hemisphere in schizophrenia. In J. Gruzelier & P. Flor-Henry (Eds.), *Hemisphere asymmetries of function in psychology.* New York: Elsevier.

Hoff, A. L., Riordan, H., & Delisi, L. E. (1992). Influence of gender on neuropsychological testing and MRI measures of schizophrenic inpatients. *Schizophrenia Bulletin, 82,* 257-272.

Hoffman, R. E., & McGlashan, T. H. (1993). Parallel distributed processing and the emergence of schizophrenia symptoms. *Schizophrenia Bulletin, 19,* 199-140.

Hollister, J. M., Laing, P., & Mednick, S. A. (1996). Rhesus incompatibility as a risk factor for schizophrenia in male adults. *Archives of General Psychiatry, 53,* 19-24.

Holzman, P. S. (1987). Recent studies in the psychophysiology of schizophrenia. *Schizophrenia Bulletin, 13,* 49-75.

Holzman, P. S., Kringlen, E., & Matthysse, S. (1988). A single dominant gene still cannot account for the transmission of schizophrenia. *Archives of General Psychiatry, 45,* 641-647.

Holzman, P. S., & Matthysse, S. (1990). The genetics of schizophrenia: A review. *Psychological Science, 1,* 279-286.

Hoving, K. L., Morin, R. E., & Konick, D. S. (1970). Recognition reaction time and size of the memory set: A developmental study. *Psychonomic Science, 21,* 247-248.

Hugdahl, K. (1988). *Handbook of dichotic listening: Theory, research and methods.* Chichester, UK: John Wiley.

Hunt, E. (1978). Mechanics of verbal ability. *Psychological Review, 85,* 104-130.

Huston, P. E., Shakow, D., & Riggs, L. A. (1937). Studies of motor function in schizophrenia: II. Reaction time. *Journal of Consulting Psychology, 16,* 39-82.

Jacob, H., & Beckman, H. (1986). Prenatal developmental disturbances in the limbic allocortex in schizophrenics. *Journal of Neural Transmission, 65,* 303-326.

Jahnke, J. C., & Nowaczyk, R. H. (1998). *Cognition.* Upper Saddle River, NJ: Prentice-Hall.

John, R. S., Mednick, S.A., & Schulsinger, F. (1982). Teacher reports as predictor of schizophrenia and borderline schizophrenia. *Journal of Abnormal Psychology, 91,* 399-413.

Johnson, O., & Crockett, D. (1982). Changes in perceptual asymmetries with clinical improvement of depression and schizophrenia. *Journal of Abnormal Psychology, 91,* 45-54.

Jones, W. P., & Anderson, J. R. (1987). Semantic categorization and high-speed scanning. *Journal of Experimental Psychology: Learning, Memory and Cognition, 8,* 237-242.

Kass, F., Skodol, A. E., Charles, E., Spitzer, R. L., & Williams, J. B. (1985). Scaled ratings of DSM-III personality disorders. *American Journal of Psychiatry, 142,* 627-630.

Karny, N., & Nachson, I. (1995). Abnormal lateralization in schizophrenia: Empirical evidence for an integrated model. *European Psychiatry, 10,* 75-84.

Keefe, R. S. E., Silverman, J. M., Mohs, R. C., Siever, L. J., Harvey, P. D., Friedman, L., Lees Roitman, S. E., DuPré, R. L., Smith, C. J., Schmeidler, J., & Davis, K. L. (1997). Eye tracking, attention, and schizotypal symptoms in nonpsychotic relatives of patients with schizophrenia. *Archives of General Psychiatry, 54,* 169-176.

Kendler, K. S., & Diehl, S. R. (1993). The genetics of schizophrenia: A current, genetic-epidemiologic perspective. *Schizophrenia Bulletin, 19,* 261-285.

Kendler, K. S., Gruenberg, A. M. (1984). An independent analysis of the Danish adoption study of schizophrenia. VI. The relationship between psychiatric disorders as defined by DSM-III in the relatives and the adoptees. *Archives of General Psychiatry, 41,* 555-564.

Kendler, K. S., Gruenberg, A. M., & Strauss, J. S. (1981). An independent analysis of the Copenhagen sample of the Danish Adoption study of schizophrenia. V. The relationship between childhood social withdrawal and adult schizophrenia. *Archives of General Psychiatry, 39,* 1257-1261.

Kendler, K. S., Masterson, C., Ungaro, R., & Davies, K. L. (1984). A family history study of schizophrenia-related personality disorders. *American Journal of Psychiatry, 141,* 424-427.

Kern, R. S., Green, M. F., & Wallace, C. J. (1997). Declarative and procedural learning in schizophrenia: A test of the integrity of divergent memory systems. *Cognitive Neuropsychiatry, 2,* 39-50.

Kety, S. S., Rosenthal, D., Wender, P. H., & Schulsinger, F. (1968). The types and prevalence of mental illness in the biological and adoptive families of adopted schizophrenics. *Journal of Psychiatric Research, 6* (Suppl.), 345-362.

Kety, S. S., Rosenthal, D., Wender, P. H., Schulsinger, F., & Jacobson, B. (1975). Mental illness in the biological and adoptive families of adopted individuals who have become schizophrenic: A preliminary report based upon psychiatric interviews. In R. Fieve, D. Rosenthal, & H. Brill (Eds.), *Genetic research in psychiatry.* Baltimore, MA: Johns Hopkins University Press.

Kety, S. S., Wender, P. H., Jacobson, B., Ingraham, L. J., Jannson, L., Faber, B., & Kinney, D. (1994). Mental illness in the biological and adoptive relatives of schizophrenic adoptees: Replication of the Copenhagen study in the rest of Denmark. *Archives of General Psychiatry, 51,* 442-455.

Kimura, D. (1961). Some effects of temporal lobe damage on auditory perception. *Canadian Journal of Psychology, 15,* 156-162.

Kimura, D. (1967). Functional asymmetry of the brain in dichotic listening. *Cortex, 3,* 163-178.

Kimura, D. (1992). Sex differences in the brain. *Scientific American, 267,* 119-125.

Kiyota, K. (1987). Dysfunction of intra- and inter-hemispheric complementarity of recognition in schizophrenics-hierarchy and laterality. In R. Takahashi, P. Flor-Henry, J. Gruuzelier, & S. Niwa (Eds.), *Cerebral dynamics, laterality, and psychopathology.* Amsterdam: Elsevier.

Klatzky, R. L., & Atkinson, R. C. (1970). Memory scans based on alternative tests stimulus representations. *Perception and Psychophysics, 8,* 113-117.

Knight, R. (1992). Specifying cognitive deficiencies in premorbid schizophrenics. *Progress in Experimental Personality and Psychopathology Research, 15,* 252-289.

Koh, S. D., Szoc, R., & Peterson, R. A. (1977). Short-term memory scanning in schizophrenic young adults. *Journal of Abnormal Psychology, 86,* 451- 460.

Kolb, B., & Whishaw, I. Q. (1983). Performance of schizophrenic patients on tests sensitive to left or right frontal, temporal, or parietal function in neurological patients. *Journal of Nervous and Mental Disease, 171,* 435-443.

Kolb, B., & Whishaw, I. Q. (1995). *Fundamentals of human neuropsychology.* New York: W. H. Freeman and Company.

Kovelman, J. A., & Scheibal, A. B. (1984). A neurohistological correlate of schizophrenia. *Biological Psychiatry, 19,* 1602-1621.

Kretschmer, E. (1925). Physique and character: An investigation of the nature of constitution and of the theory of temperament (2nd ed.). New York: Harcourt.

Kristofferson, M. (1972). When item recognition and visual search functions are similar. *Perception and Psychophysics, 12,* 379-384.

Krouse, J. P., & Kauffman, J. M. (1982). Minor physical anomalies in exceptional children: A review and critique of research. *Journal of Abnormal Child Psychology, 10,* 247-264.

Kugler, B. T., & Caudrey,D. J. (1983). Phoneme discrimination in schizophrenia. *British Journal of Psychiatry, 142,* 53-59

Laflèche, G. C., Stuss, D. T., Nelson, R. F., & Picton, T. W. (1990). Memory scanning and structured learning in Alzheimer's disease and Parkinson's disease. *Canadian Journal on Aging, 9,* 120-134.

Lenzenwegger, M. F., Cornblatt, B. A., & Putnick, M. (1991). Schizotypy and sustained attention. *Journal of Abnormal Psychology, 100,* 84-89.

Lerner, J., Nachson, I., & Carmon, A. (1977). Responses of paranoid and nonparanoid schizophrenics in a dichotic listening task. *Journal of Nervous and Mental Diseases, 164,* 247-252.

Levin, E. D., Wilson, W., Rose, J. E., & McEvoy, J. (1996). Nicotine-haloperidol interactions and cognitive performance in schizophrenics. *Neuropsychopharmacology, 15,* 429-436.

Levy, D. L., Holzman, P. S., Matthysse, S., & Mendell, N. (1993). Eye-tracking dysfunction and schizophrenia: A critical perspective. *Schizophrenia Bulletin, 19,* 461-536.

Lewine, R. J., Walker, E. F., Shurett, R., Caudle, J., & Haden, C. (1996). Sex differences in neuropsychological functioning among schizophrenic patients. *American Journal of Psychiatry, 153,* 1178-1184.

Lewis, S. W., Reveley, A. M., Reveley, M. A., Chitkara, B., & Murry, R. M. (1987). The familial/sporadic distinction as a strategy in schizophrenia research. *British Journal of Psychiatry, 151,* 306-313.

Lipton, A. A., & Cancro, R. (1995). Schizophrenia: clinical features. In H. I. Kaplan & B. J. Sadock (Eds.), *Comprehensive textbook of psychiatry VI.* Baltimore, MD: Williams & Wilkins.

Lishman, W. A., Toore, B. K., Colbourn, C. J., McMeekan, E. R. L., & Mance, R. M. (1978). Dichotic listening in psychotic patients. *British Journal of Psychiatry, 132,* 333-341.

Lively, B. L. (1972). Speed/accuracy trade-off and practice as determinants of stage durations in a memory search task. *Journal of Experimental Psychology, 96,* 97-103.

Lively, B. L., & Sanford, B. J. (1972). The use of category information in a memory search task. *Journal of Experimental Psychology, 93,* 379-385.

Loberg, E., Hugdahl, K., & Green, M. F. (1999). Hemispheric asymmetry in schizophrenia: A dual deficits model. *Biological Psychiatry, 45,* 76-81.

Lowing, P. A., Mirsky, A. F., & Pereira, R. (1983). The inheritance of schizophrenia spectrum disorders: A reanalysis of the Danish adoptee study data. *American Journal of Psychiatry, 140,* 1167-1171.

MacCrimmon, D. J., Cleghorn, J. M., Asarnow, R. F., & Steffy, R. A. (1980). Children at risk for schizophrenia: Clinical and attentional characteristics. *Archives of General Psychiatry, 37,* 671-674.

Machon, R.A., Huttunen, M. O., Mednick, S. A., & Lafosse, J. (1995). Schizotypal personality disorder characteristics associated with second trimester disturbance of neural development. In A. Raine, T. Lencz, & S. Mednick (Eds.), *Schizotypal personality.* Cambridge, MA: Cambridge University Press.

Magaro, P. A. (1980). *Cognition in schizophrenia and paranoia: The integration of cognitive processes.* Hillsdale, NJ: Erlbaum.

Magaro, P. A., & Chamrad, D. L. (1983a). Information processing and lateralization in schizophrenia. *Biological Psychiatry, 18,* 29-44.

Magaro, P. A., & Chamrad, D. L. (1983b). Hemispheric preference of paranoid and nonparanoid schizophrenics. *Biological Psychiatry, 18,* 1269-1285.

Magaro, P. A., & Page, J. (1983). Brain disconnection, schizophrenia, and paranoia. *Journal of Nervous and Mental Disease, 171,* 133-140.

Markow, T. A., & Gottesman, I. I. (1989). Fluctuating dermatoglyphic asymmetry in psychotic twins. *Psychiatry Research, 29,* 37-43.

Markow, T. A., & Wandler, K. (1986). Fluctuating dermatoglyphic asymmetry and the genetics of liability to schizophrenia. *Psychiatry Research, 19* 323-328.

Mason, O., Claridge, G., Williams, L. (1997). Questionnaire measurement. In G. Claridge (Ed.), *Schizotypy, implications for illness and health.* New York: Oxford University Press.

Matthysse, S. (1985). Genetic latent structure analysis. In T. Sakai & T. Tsuboi (Eds.), *Genetic aspects of human behavior*. Tokyo: Igaku-Shoin.

Matthysse, S., Holzman, P. S., & Lange, K. (1986). The genetic transmission of schizophrenia: Application of Mendelian latent structure analysis to eye tracking dysfunctions in schizophrenia and affective disorders. *Journal of Psychiatric Research, 20*, 57-76.

McGue, M., & Gottesman, I. I. (1989). Genetic linkage in schizophrenia: Perspectives from genetic epidemiology. *Schizophrenia Bulletin, 15*, 453-464.

McGuffin, P. (1991). Genetic models of madness. In P. McGuffin & R. Murray (Eds.), *The new genetics of mental illness*. Oxford: Butterworth-Heinemann.

Mednick, S. A., Machon, R. A., Huttunen, M. O., and Bonett, D. (1988). Adult schizophrenia following prenatal exposure to an influenza epidemic. *Archives of General Psychiatry, 45*, 189-192.

Mednick, S. A., & Schulsinger, F. (1965). A longitudinal study of children with a high risk for schizophrenia: A preliminary report. In S. G. Vanderberg (Ed.), *Methods and goals in human behavior genetics*. New York: Academic Press.

Meehl, P. E. (1962). Schizotaxia, schizotypy, schizophrenia. *American Psychologist, 17*, 827-838.

Meehl, P. E. (1989). Schizotaxia revisited. *Archives of General Psychiatry, 46*, 935-944.

Mellor, C. S. (1992). Dermatoglyphic evidence of fluctuating asymmetry in schizophrenia. *British Journal of Psychiatry, 160*, 476-472.

Merritt, R. D., & Balogh, D. W. (1984). The use of a backward masking paradigm to assess information processing deficits among schizotypics: A re-evaluation of Steronko and Woods. *Journal of Nervous and Mental Disease, 172,* 216-224.

Miller, L., & Burns, S. (1995). Gender differences in schizotypic features in a large sample of young adults. *Journal of Nervous and Mental Disease, 183,* 657-661.

Miller, S., Saccuzzo, D., & Braff, D. (1979). Information processing deficits in remitted schizophrenics. *Journal of Abnormal Psychology, 88,* 446-449.

Milner, B., Taylor, L., and Sperry, R. W. (1968). Lateralized suppression of dichotically presented digits after commissural section in man. *Science, 168,* 241-242.

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

Mirsky, A. F., Lockhead, S. J., Jones, B. P., Kugelmass, S., Walsh, D., & Kendler, K. S. (1992). On familial factors in the attentional deficit in schizophrenia: A review and a report of two new subject samples. *Journal of Psychiatric Research, 26,* 383-403.

Mishizawa, S., & Saslow, C. A. (1987). Lateralization of kinesthetically guided spatial perception. *Cortex, 23,* 485-503.

Moscovitch, M. (1979). Information processing and the cerebral hemispheres. In M. Gazzangia (Ed.), *Handbook of behavioral neurobiology.* New York: Plenum.

Moscovitch, M., Strauss, E., & Olds, J. (1981). Handedness and dichotic listening performance in patients with unipolar endogenous depression who received ECT. *American Journal of Psychiatry, 138,* 988-990.

Mosley, J. L. (1985). High-speed memory-scanning task performance of mildly mentally retarded and nonretarded individuals. *American Journal of Mental Deficiency, 90,* 81-89.

B. M., Murphy, Burke, J. G., Bray, J. C., Walsh,D., & Kendler, K. S. (1994). An analysis of the clinical features of familial schizophrenia. *Acta Psychiatrica Scandinavica, 89,* 421-427.

Murry, R. M., Lewis, S. W., & Reveley, A. M. (1985). Towards an aetiological classification of schizophrenia. *Lancet, 1,* 1023-1026.

Nachshon, I. (1980). Hemisphere dysfunction in schizophrenia. *Journal of Nervous and Mental Disease, 168,* 241-242.

Neale, J. M. (1969). Information processing and vulnerability: High-risk research. In M. J. Goldstein (Ed.), *Preventative intervention in schizophrenia: Are we ready?* Department of Health and Human Services Publication No. (ADM) 82-1111. Washington, DC: United States Government Printing Office.

Neale, J. M. (1971). Perceptual span in schizophrenia. *Journal of Abnormal Psychology, 77,* 196-204.

Necka, E. (1992). Cognitive analysis of intelligence: the significance of working memory processes. *Personality and Individual Differences, 13,* 1031-1046.

Neubauer,A. C., & Knorr, E. (1998). Three paper-and -pencil tests for speed of information processing: psychometric properties and correlations with intelligence. *Intelligence, 26,* 123-151.

Neubauer, A. C., Riemann, R., Mayer, R., & Angleiter, A. (1997). Intelligence and reaction times in the Hick, Sternberg and Posner Paradigms. *Personality and Individual Differences, 22,* 885-894.

Neufeld, R. W. J. (1977). Components of processing deficit among paranoid and nonparanoid schizophrenics. *Journal of Abnormal Psychology, 86,* 60-64.

Niwa, S. I., Hiramatso, K. I., Kameyama, T., Saitoh, O., Itoh, K., & Utena, H. (1983). Left hemisphere's inability to sustain attention over extended time periods in schizophrenics. *British Journal of Psychiatry, 142,* 477-481.

Noffsinger, D. (1985). Dichotic listening techniques in the study of hemispheric asymmetries. In D. F. Benson and E. Zaidel (Eds.), *The dual brain.* New York: Guilford.

Nopoulos, P., Flaum, M., & Andreasen, N. (1997). Sex differences in brain morphology in schizophrenia. *American Journal of Psychiatry, 154,* 1648-1654.

Nuechterlein, K. H. (1983). Signal detection in vigilance tasks and behavioral attributes among offspring of schizophrenic mothers and among hyperactive children. *Journal of Abnormal Psychology, 92,* 4-28.

Nuechterlein, K. H. (1991). Vigilance in schizophrenia and related disorders. In S. R. Steinhauer, J. H. Gruzelier, & J. Zubin (Eds.), *Handbook of Schizophrenia* (Vol. 5). Amsterdam: Elsevier.

Nuechterlein, K. H., & Dawson, M. E. (1984a). Information processing and attentional functioning in the developmental course of schizophrenic disorders. *Schizophrenia Bulletin, 11,* 264-285.

Nuechterlein, K. H., & Dawson, M. E. (1984b). A heuristic vulnerability/stress model of schizophrenic episodes. *Schizophrenia Bulletin, 10,* 300-312

Nuechterlein, K. H., Dawson, M. E., Gitlan, M., Ventura, J., Goldstein, M. J., Snyder, K. S., Yee, C. M., & Mintz, J. (1992). Developmental processes in schizophrenic disorders: Longitudinal studies of vulnerability and stress. *Schizophrenia Bulletin, 18,* 387-425.

Nuechterlein, K. H., Edell, W. S., Norris, M., & Dawson, M. E. (1986). Attentional vulnerability indicators, thought disorder, and negative symptoms. *Schizophrenia Bulletin, 12,* 408-426.

O'Callaghan, E., Larkin, C., Kinsella, A., & Waddington, J. L. (1991a). Familial, obstetric, and other clinical correlates of minor physical anomalies in schizophrenia. *American Journal of Psychiatry, 148,* 479-483.

O' Callaghan, E., Sham, P., Takei, N., Glover, G., & Murray, R. M. (1991b). Schizophrenia after prenatal exposure to 1957 A2 influenza epidemic. *Lancet, 337,* 1248-1250.

Onstad, S., Skre, I., Edvardsen, J., Torgersen, S., & Kringlen, E. (1991). Mental disorders in the first degree relatives of schizophrenics. *Acta Psychiatrica Scandinavica, 83,* 463-467.

Orzack, M. H., & Kornetsky, C. (1966). Attention dysfunction in chronic schizophrenia. *Archives of General Psychiatry, 14,* 323-326.

Paterson, A. H., Lander, E. S., & Hewitt, J. D. (1988). Resolution of quantitative traits into Mendelian factors by using a complete linkage map of restriction fragment polymorphism. *Nature, 335,* 721.

Pic'l, A. K., Magaro, P. A., & Wade, E. A. (1979). Hemispheric functioning in paranoid and nonparanoid schizophrenia. *Biological Psychiatry, 14,* 891-903.

Polymeropoulos, M. H., Coon, H., Byerley, W., Gershon, E. S., Goldin, L., Crow, T. J., Rubenstein, J., Hoff, M., Hloik, J., & Smith, A. M. (1994). Search for a schizophrenia susceptibility locus on human chromosome 22. *American Journal of Medical Genetics, 54,* 93-99.

Prescott, C. A., & Gottesman, I. I. (1993). Genetically mediated vulnerability to schizophrenia. *Psychiatric Clinics of North America, 2,* 245-267.

Prescott, C. A., Strauss, M. E., & Tune, L. E. (1986). Test-retest reliability of information processing measures among chronic schizophrenics. *Psychiatric Research, 17,* 199-202.

Priebe, S., Warner, R., Hubschmid, T., & Eckle, I. (1998). Employment, attitudes toward work, and quality of life among people with schizophrenia in three countries. *Schizophrenia Bulletin, 24,* 469-477.

Puckett, J. M., & Kausler, D. H. (1984). Individual differences and models of memory span: A role for memory search rate? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10,* 72-82.

Pulver, A. E., Karayiorgou, M., Lasseter, V. K., Wolyneic, P., Kasch, L., Antonarakis, S., Housman, D., Kazazian, H. H., Meyer, D., & Nestadt, G. (1994). Follow-up of a report of a potential linkage for schizophrenia on chromosome 22q12-q13.1: Part II. *American Journal of Medical Genetics, 54,* 44-50.

Pulver, A. E., Karayiorgou, M., Wolyneic, P., Lasseter, V., Nestadt, G., Antonarakis, S., Housman, D., Kazazian, H. H., & Meyer, D. (1994). Sequential strategy to identify a susceptibility gene for schizophrenia on chromosome 22q12-q13.1: Part I. *American Journal of Medical Genetics, 54,* 36-43.

Purcell, D. W., Lewine, R. J., Caudle, J, & Price, L. R. (1998). Sex differences in verbal IQ/performance IQ discrepancies among patients with schizophrenia and normal volunteers. *Journal of Abnormal Psychology, 107,* 161-165.

Rado, S. (1953). Dynamics and classification of disordered behavior. *American Journal of Psychiatry, 110,* 406-416.

Ragland, D. J., Goldberg, T. E., Wexler, B. E., Gold, J. M., Torrey, F. E., & Weinberger, W. R. (1992). Dichotic listening in monozygotic twins discordant and concordant for schizophrenia. *Schizophrenia Research, 7,* 177-183.

Raine, A., Andrews, H., Sheard, C., Walder, C., & Manders, D. (1989). Interhemispheric transfer in schizophrenics, depressives, and normals with schizoid tendencies. *Journal of Abnormal Psychology, 98,* 31-41.

Raine, A., Harrison, G. N., Reynolds, G. P., Sheard, C., Cooper, J. E., & Medley, I. (1990). Structural and functional characteristics of the corpus callosum in schizophrenics, psychiatric controls, and normal controls. *Archives in General Psychiatry, 47,* 1060-1064.

Rasmussen, T., & Milner, B. (1977). The role of early left brain injury in determining lateralization of cerebral speech functions. *Annals of the New York Academy of Sciences, 299,* 355-359.

Raine, A., & Manders, D. (1988). Schizoid personality, interhemispheric transfer, and left hemisphere overactivation. *British Journal of Clinical Psychology, 27,* 333-347.

Rawlings D., & Borge, A. (1987). Personality and hemisphere function: Two experiments using the dichotic shadowing technique. *Personality and Individual Differences, 8,* 483-488.

Rawlings, D., & Claridge, G. (1984). Schizotypy and hemisphere function: III. Performance asymmetries on tasks of letter recognition and local-global processing. *Personality and Individual Differences, 5,* 657-663.

Reite, M., Sheeder, J., Teale, P., Richardson, D., Adams, M., & Simon, J. (1995). MEG bases brain laterality: Sex differences in normal adults. *Neuropsychologia, 33,* 1607-1616.

Repp, B. H. (1977). Stimulus dominance and ear dominance in the perception of dichotic voicing contrasts. *Brain and Language, 5,* 310-330.

Reveley, M. A., Reveley, A. M., & Baldy, R. (1987). Left cerebral hemisphere hypodensity in discordant schizophrenic twins: A controlled study. *Archives of General Psychiatry, 44,* 625-632.

Risch, N. (1990). Genetic linkage and complex diseases, with special reference to psychiatric disorders. *Genetic Epidemiology, 7,* 3-16.

Risch, N., & Baron, M. (1984). Segregation analysis of schizophrenia and related disorders. *American Journal of Human Genetics, 36,* 1039-1059.

Romney, D. M. (1987). A simplex model of the paranoid process: Implications for diagnosis and prognosis. *Acta Psychiatrica Scandinavica, 75,* 651-655.

Romney, D. M. (1990). Thought disorder in the relatives of schizophrenics: A meta-analytic review of selected studies. *Journal of Nervous and Mental Disease, 178,* 481-486.

Rosanoff, A. J. (1911). A study of heredity in insanity in light of the Mendelian theory. *American Journal of Insanity, 68,* 211-261.

Rosenthal, R., & Bigelow, L. B. (1972). Quantitative brain measures in chronic schizophrenia. *British Journal of Psychiatry, 121,* 259-264.

Rosenthal, D., Wender, P. H., Kety, S. S., Schulsinger, F., Welner, J., & Oatergaad, L. (1968). Schizophrenics' offspring reared at home. In D. Rosenthal, S. S. Kety (Eds.), *The transmission of schizophrenia.* New York: Pergamon.

Rosenthal, D., Wender, P. H., Kety, S. S., Welner, J., & Schulsinger, F. (1971). The adopted away offspring of schizophrenics. *American Journal of Psychiatry, 128,* 307-311.

Rosvold, H. E., Mirsky, A. F., Sarason, I., Bransome, E. D., & Beck, L. H. (1956). A continuous performance test of brain damage. *Journal of Consulting Psychology, 20,* 343-350.

Roznowski, M., & Smith, M. L. (1993). A note on some psychometric properties of Sternberg task performance: Modification to content. *Intelligence, 17,* 389-398.

Saccuzzo, D. P., & Braff, D. L. (1981). Early information processing deficits in schizophrenia. *Archives of General Psychiatry, 38,* 175-179.

Saccuzzo, D. P., & Schubert, D. L. (1981). Backward masking as a measure of slow processing in schizophrenia spectrum disorders. *Journal of Abnormal Psychology, 90,* 305-312.

Satz, P., & Green, M. F . (1999). Atypical Handedness in Schizophrenia: Some methodological and theoretical issues. *Schizophrenia Bulletin, 25,* 63-78

Schmitter-Edgecombe, M. E., Marks, W. , Fahy, J. F., & Long, C. J. (1992). Effects of severe closed-head injury on three stages of information processing. *Journal of Clinical and Experimental Neuropsychology, 14,* 717-737.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review, 84,* 1-66.

Schwartz, B. D., Evans, W. J., Pena, J. M., & Winstead, D. K. (1994). Visible persistence decay rates for schizophrenics and substance abusers. *Biological Psychiatry, 36,* 662-669.

Seamon, J. G. (1972). Imagery codes and human information retrieval. *Journal of Experimental Psychology, 96,* 468-470.

Searleman, A., Herrmann, D. (1994). *Memory from a broader perspective.* New York: McGraw-Hill.

Seeman, M. V. (1986). Current outcomes in schizophrenia: Women versus men. *Acta Psychiatrica Scandinavica 73,* 609-617.

Seidman, L. J., Pebble, J. R., Faraone, S. V., Kremen, W. S., Green, A. I., Brown, W. A., & Tsuang, M. T. (1993). Neuropsychological performance in chronic schizophrenia in response to neuroleptic dose reduction. *Biological Psychiatry, 33,* 575-584.

Selemon, L. D., Rajkowska, G., & Goldman-Rakic, P. S. (1995). Abnormally high neuronal density in the schizophrenic cortex. *Archives of General Psychiatry, 52,* 805-818.

Servan-Schreiber, D., Cohen, J. D., & Steingard, S. (1996). Schizophrenic deficits in the processing of context: A test of neural network simulations of cognitive functioning in schizophrenia. *Archives of General Psychiatry, 53,* 1105-1112.

Sherrington, R., Brynjolfsson, J., Peturrson, H., Potter, M., Dudleston, K., Barraclough, B., Wasmuth, J., Dodds, M., & Gurling, H. (1988).

Localization of a susceptibility locus for schizophrenia on chromosome 5. *Nature, 336,* 164-167.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review, 84,* 127-190.

Siever, L. J., Silverman, J. M., Horvath, T. B., Klar, H., Coccaro, E., Keefe, R. S., Pinkham, L., Rinaldi, P., Mohs, R. C., & Davis, K. L. (1990). Increased morbid risk for schizophrenia-related disorders in relatives of schizotypal personality disordered patients. *Archives of General Psychiatry, 47,* 634-640.

Sininger, Y. S., Klatzky, R. L., & Kirchner, D. M. (1989). Memory scanning speed in language-disordered children. *Journal of Speech and Hearing Research, 32,* 289-297.

Sparks, R., & Geschwind, N. (1968). Dichotic listening in man after section of neocortical commissures. *Cortex, 4,* 3-16.

Speaks, C., Carney, E., Niccum, N., & Johnson, C. (1981). Stimulus dominance in dichotic listening. *Journal of Speech and Hearing Research, 24,* 430-437.

Sperling, G. (1960). The information available in brief visual presentations. *Psychological Monographs, 74.*

Sperry, R. W. (1982). Forebrain commissurotomy and conscious awareness. In J. Orbach (Ed.), *Neuropsychology after Lashley.* Hillsdale, NJ: Erlbaum.

Spitzer, R. L., Endicott, J., & Gibbon M. (1979). Crossing the border into borderline personality and borderline schizophrenia. *Archives of General Psychiatry, 36,* 17-24.

Spivak, B., Karny, N., Katz, G., & Radwan, M. (1996). Functional hemisphere imbalance in patients with paranoid or disorganized schizophrenia. *European Psychiatry, 11*, 175-179.

Spring, B., Lemon, M., & Fergeson. (1990). Vulnerabilities to Schizophrenia: Information-Processing Markers. In E.R. Straube & K. Hahlweg (Eds.), *Schizophrenia, concepts, vulnerability, and intervention.* New York: Springer-Verlag.

Spring, B., & Zubin, J. (1978). Attention and information processing as indicators of vulnerability to schizophrenic episodes. In L. Wynne, R. Cromwell, & S. Matthysse (Eds.), *Nature of schizophrenia: New findings and future strategies.* New York: Wiley

Squire, L. R. (1992). Declarative and nondeclarative memory: Multiple brain systems supporting learning and memory. *Journal of Cognitive Neuroscience, 4*, 232-243.

Squire, L. R., & Zola-Morgan, S. (1988). Memory: Brain systems and behavior. *Trends in Neuroscience, 11*, 170-175.

Steinhauer, S. R., Zubin, J., Condray, R., Shaw, D. B., Peters, J. L., & van Kammen, D. P. (1991). Electrophysiological and behavioral signs of attentional disturbance in schizophrenics and their siblings. In C. A. Tamminga & S. C. Schulz (Eds.), *Schizophrenia Research: Advances in Neuropsychiatry and Psychopharmacology,* Vol. 1. New York: Raven Press.

Sternberg, S. (1966). High-speed scanning in human memory. *Science, 153*, 652-654.

Sternberg, S. (1969a). Memory-scanning: Mental processes revealed by reaction time experiments. *American Scientist, 57*, 421-457.

Sternberg, S. (1969b). The discovery of processing stages: An extension of Donders' method. *Acta Psychologia, 30,* 276-315.

Sternberg, S. (1975). Memory scanning: New findings and current controversies. *Quarterly Journal of Experimental Psychology, 27,* 1-32.

Stranburg, R. J., Marsh, J. T., Brown, W. S., Asarnow, R. F., & Guthrie, D. (1984). Event related potential concomitants of information processing dysfunction in schizophrenic children. *Electroencephalography and Clinical Neurophysiology, 57,* 236.

Strauss, E., Kosaka, B., & Wada, J. (1985). Visual laterality effects and cerebral speech dominance determined by the carotid Amytal test. *Neuropsychologia, 23,* 567- 570.

Susser, E. S., & Lin, S. P. (1992). Schizophrenia after prenatal exposure to the Dutch Hunger Winter of 1944-45. *Archives of General Psychiatry, 49,* 983-988.

Susser, E. S., Neugebauer, R., Hoek, H., Brown, A. S., Lin, S., Labovitz, D., & Gorman, G. M. (1996). Schizophrenia after prenatal famine. *Archives of General Psychiatry, 53,* 25-31.

Swinney, D. A., & Taylor, O. L. (1974). Short-term memory recognition search in aphasia. *Journal of Speech and Hearing Research, 14,* 578-588.

Thaker, G., Adami, H., Moran, M., Lahti, A., & Cassady, S. (1993). Psychiatric illnesses in families of subjects with schizophrenia-spectrum personality disorders: High morbidity risks for unspecified functional psychoses and schizophrenia. *American Journal of Psychiatry, 150,* 66-71.

Theios, J., Smith, P., Haviland, S., Traupmann, J., & Moy, M. (1973). Memory scanning as a serial self-terminating process. *Journal of Experimental Psychology, 97*, 323-326.

Tienari, P., Kaleva, M., Lahti, I., Laksy, K., Moring, J., Naarala, M., Sorri, A., Wahlberg, K. E., & Wynne, L. (1991). Adoption studies on schizophrenia. In C. Eggers (Ed.), *Schizophrenia and Youth.* Berlin: Springer.

Tienari, P., Lahti, I., Sorri, A., Nasarala, M., Moring, J., & Wahlberg, K. E. (1989). The Finnish adoptive family study of schizophrenia. Possible joint effects of genetic vulnerability and family environment. *British Journal of Psychiatry, 155*, (Suppl. 5), 29-32.

Tienari, P., Sorri, A., Lahti, I., Nasarala, M., Wahlberg, K. E., Ronkko, T., Pohhola, J., & Moring, J. (1985). The Finnish adoption family study of schizophrenia. *The Yale Journal of Biology and Medicine, 58*, 227-237.

Townsend, J. T. (1971). A note on the identifiability of parallel and serial processes. *Perception & Psychophysics, 10*, 161-163.

Townsend, J. T. (1990). Serial and parallel processing: Sometimes they look like Tweedledum and Tweedledee but they can (and should) be distinguished. *Psychological Science, 1*, 46-54.

Townsend, J. T., & Van Zandt, T. (1990). New theoretical results on testing self-terminating vs. exhaustive processing in rapid search experiments. In H. G. Geissler (Ed.), *Psychological explorations of mental structures.* Toronto: Hogrefe & Huber.

Tsuang, M. T., & Faraone, S., V. (1996). Epidemiology and behavioral genetics of schizophrenia. In S. J. Watson (Ed.), *Biology of schizophrenia and affective disorders.* Washington, DC: American Psychiatric Press.

Tsuang, M. T., Gilbertson, M. W., & Faraone, S. V. (1991). Genetic transmission of negative and positive symptoms in biological relatives of schizophrenics. In A. Merneros, M. Tsuang, & N. Adreasen (Eds.), *Positive and negative schizophrenia*. Berlin: Springer.

Tsuang, M. T., Winokur, G., & Crowe, R. R. (1980). Morbidity risks of schizophrenia and affective disorders among first degree relatives of patients with schizophrenia, mania, depression, and surgical conditions. *British Journal of Psychiatry, 137*, 497-504.

Tucker, D. (1981). Lateral brain function, emotion, and conceptualization. *Psychological Bulletin, 89*, 19-46.

Vanderplas, J. M., & Garvin, E. A. (1959). The association value of random shapes. *Journal of Experimental Psychology, 57*, 147-154.

Vogler, G. P., Gottesman, I. I., McGue, M. K., & Rao, D. C. (1990). Mixed model segregation analysis of schizophrenia in the Lindelius Swedish degrees. *Behavior Genetics, 20*, 461-472.

Walker, E. F. (1994). Developmentally moderated expressions of the neuropathology underlying schizophrenia. *Schizophrenia Bulletin, 20*, 453-480.

Walker, E. F., & DiForio, D. (1997). Schizophrenia: A neural diathesis-stress model. *Psychological Review, 104*, 667-685.

Walker, E. F., Grimes, K. E., Davis, D. N., & Smith, A. J. (1993). Childhood precursors of schizophrenia: Facial expressions of emotions. *American Journal of Psychiatry, 150*, 1654-1660.

Walker, E. & Harvey, P. (1986). Positive and negative symptoms in schizophrenia: Attentional performance correlates. *Psychopathology, 19,* 294-302.

Walker, E. F., & McGuire, M. (1982). Intra- and interhemispheric information processing in schizophrenia. *Psychology Bulletin, 92,* 701-725.

Walker, E. F., Savoie, T., & Davis, D. (1994). Neuromotor precursors of schizophrenia. *Schizophrenia Bulletin, 20,* 441-451.

Weinberger, D. R. (1987). Implications of normal brain development for the pathogenesis of schizophrenia. *Archives of General Psychiatry, 44,* 660-670.

Weinberger, D. R. (1995). From neuropathology to neurodevelopment. *Lancet, 346,* 552-557.

Weinberger, D. R., & Gallhofer, B. (1997). Cognitive function in schizophrenia. *International Clinical Psychopharmacology, 12* (Suppl 4), 29-36.

Weinberger, D. R., & Lipska, B. K. (1995). Cortical maldevelopment, anti-psychotic drugs, and schizophrenia: A search for a common ground. *Schizophrenia Research, 16,* 87-110.

Weintraub, S. (1987). Risk factors in schizophrenia: The Stony Brook high-risk project. *Schizophrenia Bulletin, 13,* 439-450.

Wexler, B. E. (1986). Alterations in cerebral laterality during acute psychotic illness. *British Journal of Psychiatry, 149,* 202-209.

Wexler, B. E., Giller, E. L., & Southwick, S. M. (1991). Cerebral laterality, symptoms, and diagnosis in psychotic patients. *Biological Psychiatry, 29,* 103-116.

Wexler, B. E., & Halwes, T. (1985). Dichotic listening tests in studying brain-behavior relationships. *Neuropsychologia, 23,* 545-559.

Wexler, B. E., & Heninger, G. R. (1979). Alterations in cerebral laterality during acute psychotic illnesses. *Archives of General Psychiatry, 36,* 278-284.

Williams, S. M., Cooper, C., & Hunter, J. A. (1990). A response-type reaction time effect found in the S. Sternberg high-speed memory scanning paradigm. *Acta Psychologica, 75,* 279-292.

Wishner, J., Stein, M. K., & Peastrel, A. L. (1977). Stages of information processing in schizophrenia: Sternberg's paradigm. In L. C. Wynne, R. L. Cromwell, & S. Matthysse (Eds.), *The nature of schizophrenia: New approaches to research and treatment* (pp. 233-243). New York: Wiley.

Witelson, S. F., & Kigar, D. L. (1992). Sylvian fissure morphology and asymmetry in men and women: Bilateral differences in relation to handedness in men. *Journal of Comparative Neurology, 323,* 326-340.

Wohlberg, G. W., & Kornetsky, C. (1973). Sustained attention in remitted schizophrenics. *Archives of General Psychiatry, 28,* 533-537.

Wyatt, R. J. (1996). Neurodevelopmental abnormalities and schizophrenia: A family affair. *Archives of General Psychiatry, 53,* 11-15.

Yates, A. J. (1966). Psychological deficits. *Annual Review of Psychology, 17,* 11-114.

Yeni-Komshian, G. H., & Gorden, J. F. (1974). The effect of memory load on the right ear advantage in dichotic listening. *Brain and Language, 1,* 375-381.

Zaidel, E. (1985). Language in the right hemisphere. In F. Benson and E. Zaidel (Eds.), *The dual brain: Hemispheric specialization in humans.* New York; Guilford Press.

Zigler, E., Glick, M., & Marsh, A. (1980). Premorbid social competence and outcome among schizophrenic and nonschizophrenic patients. *Journal of Nervous and Mental Disease, 167,* 478-483.

Zubin, J., & Spring, B. (1977). Vulnerability: A new view of schizophrenia. *Journal of Abnormal Psychology, 86,* 103-126.

THE UNIVERSITY OF
CALGARY
Faculty of SOCIAL SCIENCES
Department of PSYCHOLOGY

Appendix A

November, 1994

We would appreciate your help by participating in a research project. The project is designed to investigate performance on tests of information processing. This would involve two sessions (one and a half hours each) doing various tasks like listening and responding to sounds played through headphones and viewing and responding to objects on a computer screen.

Although this project is not related to your treatment, your participation is greatly encouraged. If you are interested in participating in the project, tell your therapist. Shelley Dickens, a research assistant with the project, will then get in touch with you to explain it in more detail.

2500 University Drive N.W., Calgary, Alberta, Canada T2N 1N4
Telephone (403) 220-5561 Fax (403) 282-8249

Appendix B

THE UNIVERSITY OF
CALGARY
Faculty of SOCIAL SCIENCES
Department of PSYCHOLOGY

INFORMED CONSENT FORM

I understand that I am being asked to participate in a project designed to investigate the association between symptom patterns in certain psychiatric disorders and performance on tests of information processing. The study will begin with a short vision and hearing test. After this, there are three tasks that we would like you to perform. Each of the tasks is designed to determine how people process information.

In the first task you will see letters or symbols that are both familiar and unfamiliar to you. You will be asked to say whether the letter (or symbol) is part of a letter (or symbol) group that you have learned for this task. In the second task you will hear pairs of sounds and will be asked to report whether the sounds you hear are the same as or different from another sound. The sounds will be presented through headphones. In the third task you will see pairs of letters (or polygons) and will be asked to report whether the letters (or polygons) are the same as or different from another letter (or polygon).

In total the time required for these tasks will be about three hours. The tasks will be given in two separate sessions with no session taking more than one and a half hours. The sessions will be scheduled at your convenience.

I understand that all data and information will be strictly confidential and that my name and address will not be mentioned in any written or oral report that is developed as part of the project. Only a code number will be used on all questionnaires and data sheets. I understand that I can withdraw from the study at any time without having to give a reason and that withdrawal from the study will have no effect on any treatment that I might be receiving. I understand that I will be reimbursed for the out-of-pocket expenses relating to my participation in this research project (e.g., public transportation, hospital parking).

I voluntarily consent to participate in this study.

Name _____

Signature _____

Date _____

Witness _____

2500 University Drive N.W., Calgary, Alberta, Canada T2N 1N4
Telephone (403) 220-5561 Fax (403) 282-8249

Appendix C

THE UNIVERSITY OF
CALGARY
Faculty of SOCIAL SCIENCES
Department of PSYCHOLOGY

PERMISSION TO CONTACT FAMILY

I understand that I am being asked to allow Shelley Dickens, research assistant, to contact my close relatives which might include sisters, brothers, mother, and father. The purpose of contacting my close relatives is to ask if they will participate in a project designed to investigate their performance on tests of information processing.

I understand that they will participate in the same tasks as I did and will require the same amount of time (approx. 3 hrs.).

I understand that their data will be strictly confidential and that their names will not be mentioned in any written or oral report that is developed as part of the project. Only a code number will be used on all questionnaires and data sheets.

I understand that my relatives may refuse to participate and will be able to withdraw from the study at any time without having to give a reason. Their participation or non-participation in the study will have no effect on any treatment that I may be receiving.

I voluntarily consent to allow the research assistant to contact my relatives to ask if they will participate in this study.

NAME_____

SIGNATURE_____

DATE_____

WITNESS_____

2500 University Drive N.W., Calgary, Alberta, Canada T2N 1N4
Telephone (403) 220-5561 Fax (403) 282-8249

Appendix D

Schizotypal Personality Scale

Claridge and Broks (1984)

1.	Do you believe in telepathy?	Yes	No
2.	Do you often feel that other people have it in for you?	Yes	No
3.	When in the dark do you often see shapes and forms even though there's nothing there?	Yes	No
4.	Does your voice ever seem distant, far away?	Yes	No
5.	Does it often happen that almost every thought immediately and automatically suggests an enormous number of ideas?	Yes	No
6.	Do you ever become oversensitive to light or noise?	Yes	No
7.	Do you often have vivid dreams that disturb your sleep?	Yes	No
8.	When you are worried or anxious do you have trouble with your bowels?	Yes	No
9.	Have you ever felt when you look in a mirror that your face seemed different?	Yes	No
10.	Do you feel it is safer to trust nobody?	Yes	No
11.	Do things sometimes feel as if they are not real?	Yes	No
12.	Do you feel lonely most of the time even when you're with people?	Yes	No
13.	Do everyday things sometimes seem unusually large or small?	Yes	No
14.	Are you often bothered by the feeling that people are watching you?	Yes	No
15.	Do you feel that you cannot get 'close' to other people?	Yes	No
16.	Do you dread going into a room by yourself where other people have already gathered and are talking?	Yes	No

Schizotypal Assessment Scale (continued)

17.	Does your sense of smell sometimes become unusually strong?	Yes	No
18.	Are you sometimes sure that other people can tell what you are thinking?	Yes	No
19.	Have you ever had the sensation of your body or part of it changing shape?	Yes	No
20.	Do you ever feel sure that something is about to happen even though there doesn't seem to be any reason for your thinking that?	Yes	No
21.	Do you ever suddenly feel distracted by distant sounds that you are not normally aware of?	Yes	No
22.	Do you ever have a sense of vague danger or sudden dread for reasons that you do not understand?	Yes	No
23.	Have you ever thought you heard people talking only to discover that it was in fact some nondescript noise?	Yes	No
24.	Do your thoughts ever stop suddenly causing you to interrupt what you're saying?	Yes	No
25.	Do you feel that you have to be on your guard even with your friends?	Yes	No
26.	Do you ever feel that your thoughts don't belong to you?	Yes	No
27.	When in a crowded room do you often have difficulty in following a conversation?	Yes	No
28.	Do you sometimes feel that your accidents are caused by mysterious forces?	Yes	No
29.	Do you sometimes feel that people are talking about you?	Yes	No
30.	Do you believe that dreams can come true?	Yes	No
31.	Do you ever feel that your speech is difficult to understand because the words are all mixed up and don't make sense?	Yes	No

Schizotypal Assessment Scale (continued)

32.	Are your thoughts sometimes so strong that you can almost hear them?	Yes	No
33.	When coming to a new situation, have you ever felt strongly that it was a repeat of something that has happened before?	Yes	No
34.	Have you ever felt that you are communicating with another person telepathically?	Yes	No
35.	Are you easily distracted from work by daydreams?	Yes	No
36.	Are you very hurt by criticism?	Yes	No
37.	Do you ever get nervous when someone is walking behind you?	Yes	No

Appendix E

Means and Standard Deviations for Chronological Age and Verbal IQ

	Schizophrenia Group		Psychiatric Control		Non-psychiatric Control		Nonschizotypal Parent		Nonschizotypal Sibling		Schizotypal Parent		Schizotypal Sibling		Total	
	n=30		n=15		n=20		n=13		n=7		n=9		n=8		n=102	
Variable	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Age	31.3	7.6	36.6	11.0	32.8	10.8	56.5	10.2	36.3	5.0	58.0	6.9	34.3	10.1	38.5	13.4
Verbal IQ	93.9	9.5	95.5	7.3	99.3	8.4	120.6	15.0	104.1	10.4	110.8	15.8	116.8	17.0	102.7	14.6

Appendix F

Frequency of Males and Females for the Groups

	Schizophrenia Group	Psychiatric Control	Non-psychiatric Control	Nonschizotypal		Schizotypal		Total
				Parent	Sibling	Parent	Sibling	
Variable	n=30	n=15	n=20	n=13	n=7	n=9	n=8	n=102
Male	76.7% n=23	20.0% n=3	75.0% n=15	46.2% n=6	42.9% n=3	22.0% n=2	25.0% n=2	53.0% n=54
Female	23.3% n=7	80.0% n=12	25.0% n=5	53.8% n=7	57.1% n=4	78.0% n=7	75.0% n=6	47.0% n=48

Appendix G

Breakdown of Marital Status

Variable	Schizophrenia n=30	Psychiatric Control n=15	Nonpsychiatric Control n=20	Nonschizotypal Relative n=20	Schizotypal Relative n=17	Total n=102
Married	0% n=0	66.6% n=10	15% n=3	80.0% n=16	52.9% n=9	37.3% n=38
Never Married	93.3% n=28	20% n=3	80% n=16	10.0% n=2	11.8% n=2	50.0% n=51
Divorced	6.7% n=2	13.3% n=2	5.0% n=1	10.0% n=2	17.6% n=3	9.8% n=10
Widowed	0% n=0	0% n=0	0% n=0	0% n=0	17.6% n=3	2.9 n=3

Appendix H

Breakdown of Education by Group

Variable	Schizophrenia n=30	Psychiatric Control n=15	Nonpsychiatric Control n=20	Nonschizotypal Relative n=20	Schizotypal Relative n=17	Total n=102
Primary	0% n=0	0% n=0	0% n=0	0% n=0	5.8% n=1	1.0% n=1
Secondary	66.6% n=20	40.0% n=6	20.0% n=4	50.0% n=10	64.7% n=11	50.0% n=51
College or Other	25.5% n=7	33.3% n=5	35.0% n=7	25.0% n=5	17.6 n=3	26.5% n=27
University	7.9% n=3	26.6% n=4	45.0% n=9	25.0% n=5	11.8% n=2	22.5% n=23

Appendix I

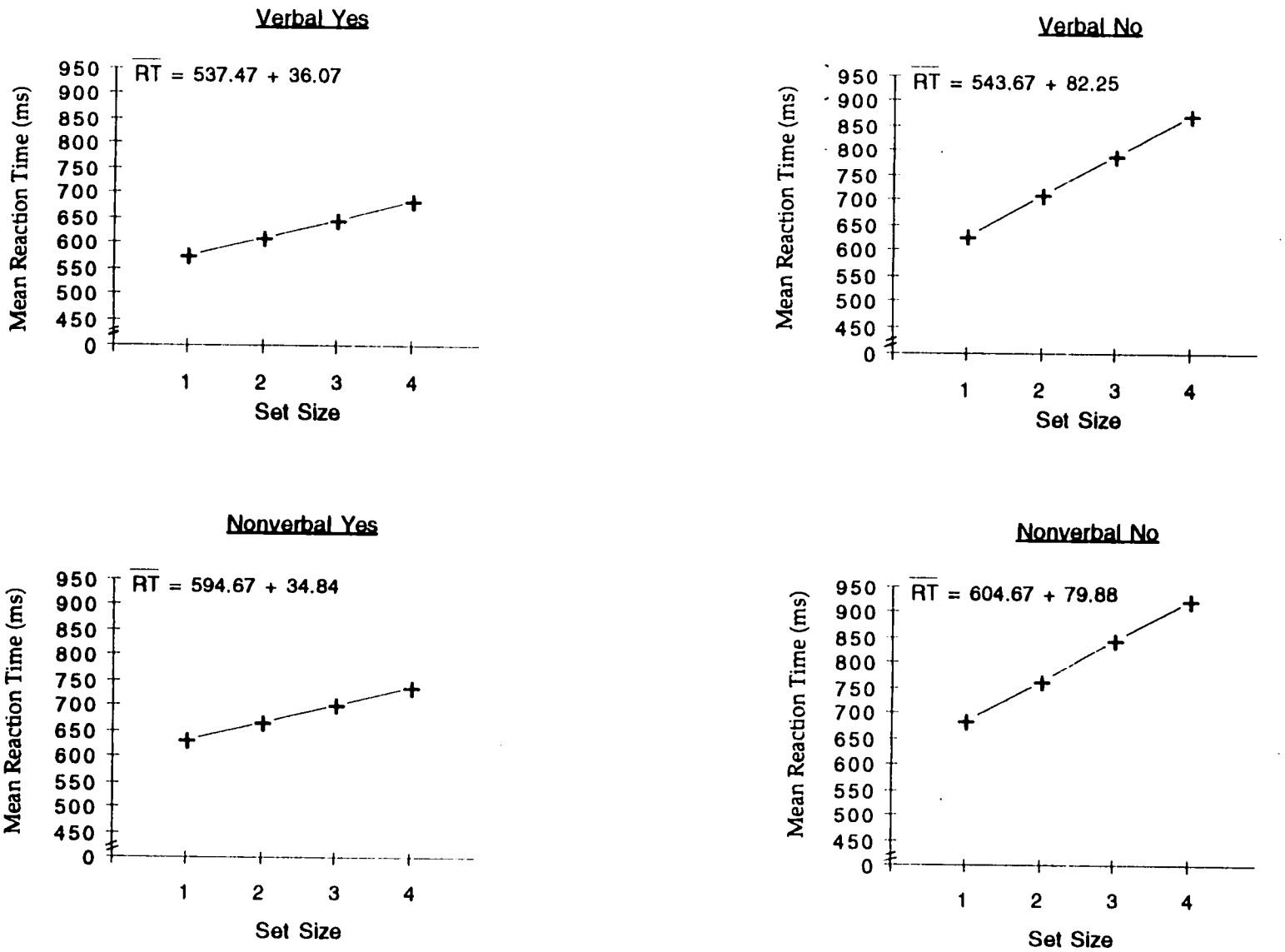
Breakdown of Occupational Levels for the Groups

Variable	Schizophrenia n=30	Psychiatric Control n=15	Nonpsychiatric Control n=20	Nonschizotypal Relative n=20	Schizotypal Relative n=17	Total n=102
Professional	6.6% n=2	13.3% n=2	35% n=7	10% n=2	5.9% n=1	13.7% n=14
Technician	0% n=0	0% n=0	5% n=1	5% n=1	5.9% n=1	2.9% n=3
Trade/Laborer	0% n=0	0% n=0	5% n=1	20% n=4	11.8% n=2	6.9% n=7
Clerical/Sales/ Service	.3% n=1	40% n=6	20% n=4	35% n=7	11.8% n=2	19.6% n=20
Unemployed	86.7% n=26	33.3% n=5	5% n=1	15% n=3	23.5% n=4	38.2% n=39
Student	3.3% n=1	13.3% n=2	30% n=6	0% n=0	11.8% n=2	10.8% n=11
Retired	0% n=0	0% n=0	0% n=0	15% n=3	29.4% n=5	7.8% n=8

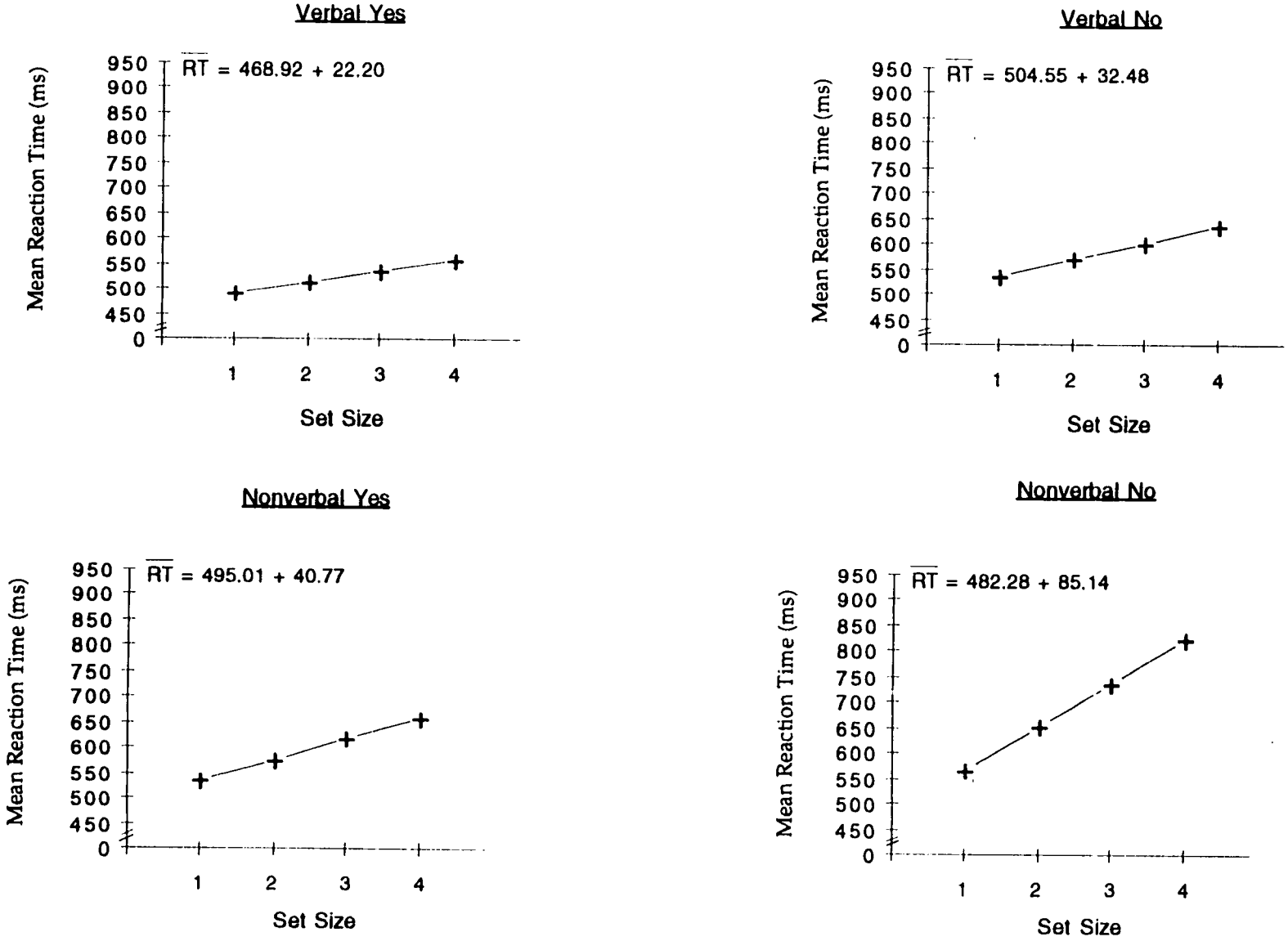
Appendix J

Mean and Standard Deviation for the Schizotypal Personality Scale

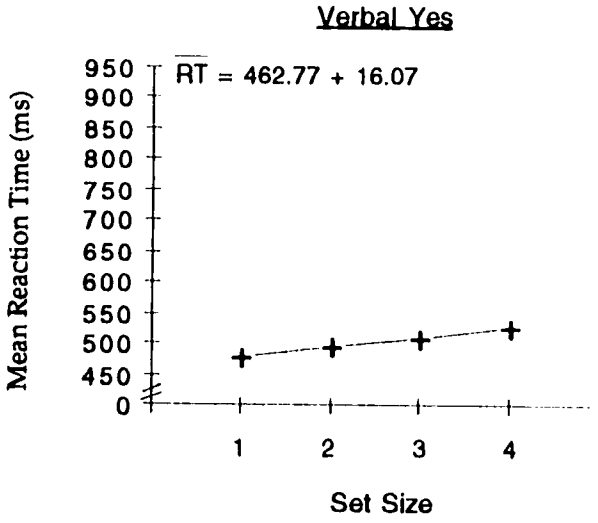
	Nonschizotypal				Schizotypal				Total	
	Parent		Sibling		Parent		Sibling			
	n=13		n=7		n=9		n=8		n=37	
Variable	M	SD	M	SD	M	SD	M	SD	M	SD
SPS Score	4.8	2.8	5.0	2.3	15.5	4.4	14.9	4.7	9.6	6.3

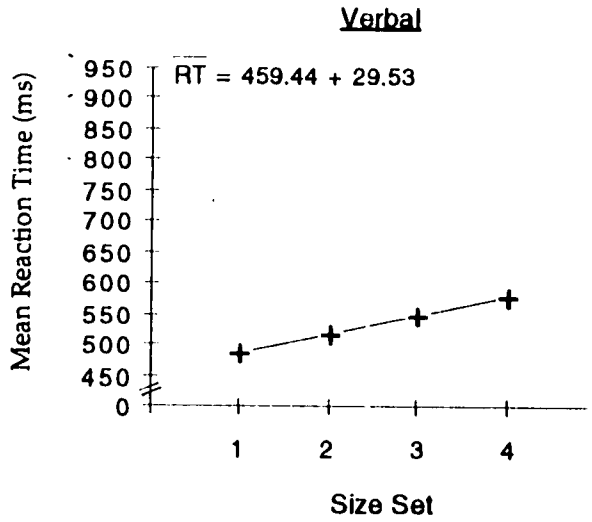


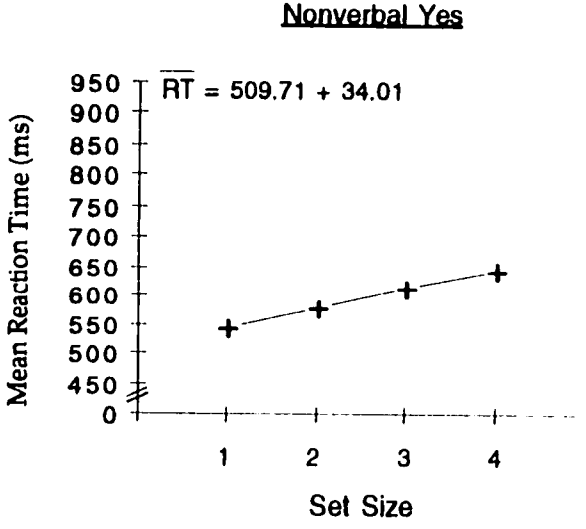
Appendix K.1. Mean Regression Line for Verbal Yes, Verbal No, Nonverbal Yes, and Nonverbal No Responses of the Schizophrenia Group (n = 30).

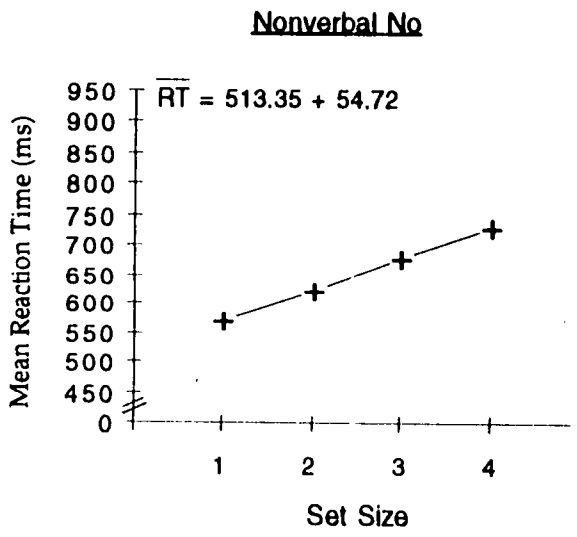


Appendix K.2. Mean Regression Line for Verbal Yes, Verbal No, Nonverbal Yes, and Nonverbal No Responses of the Psychiatric Control Group (n = 15).

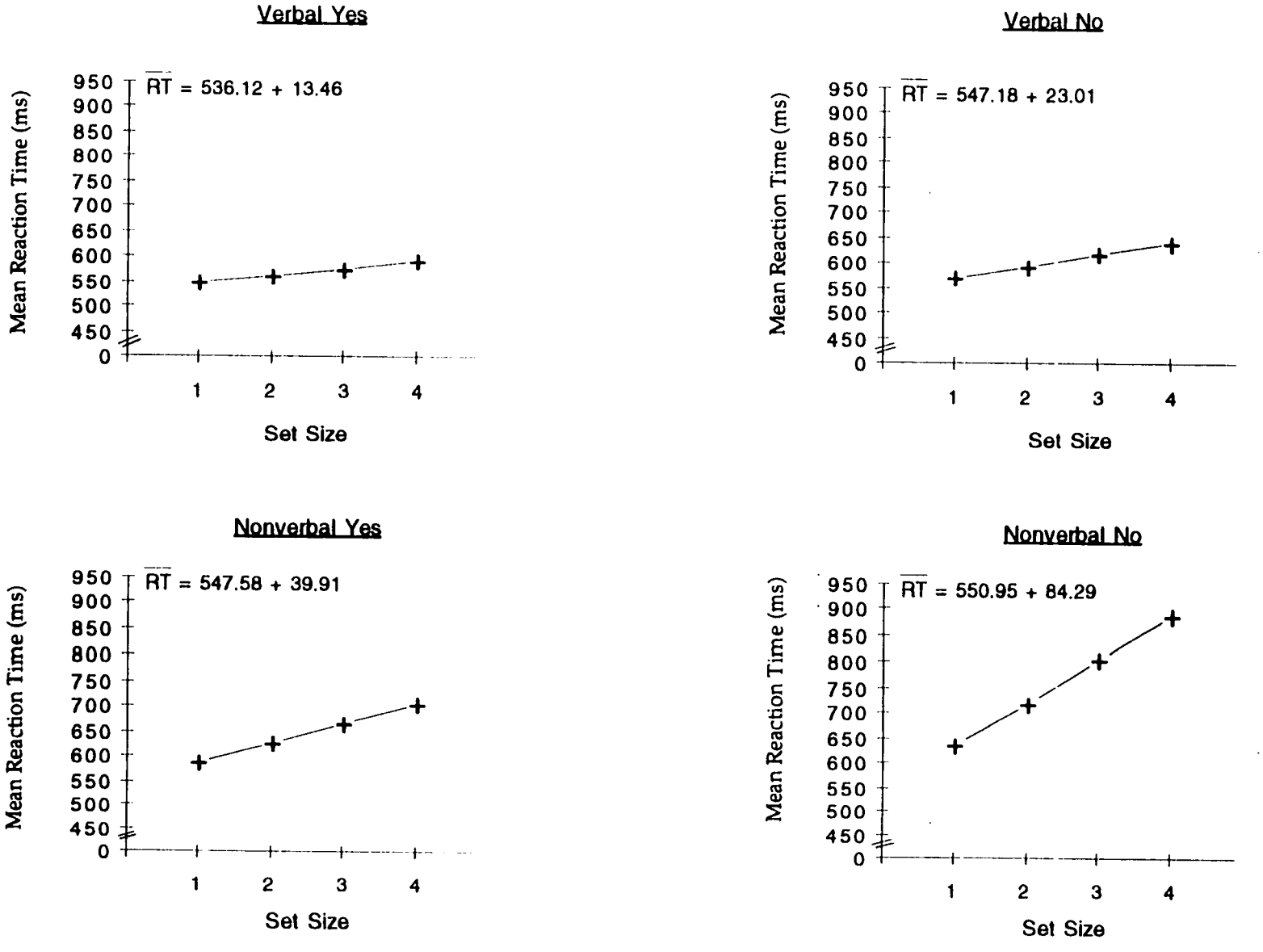




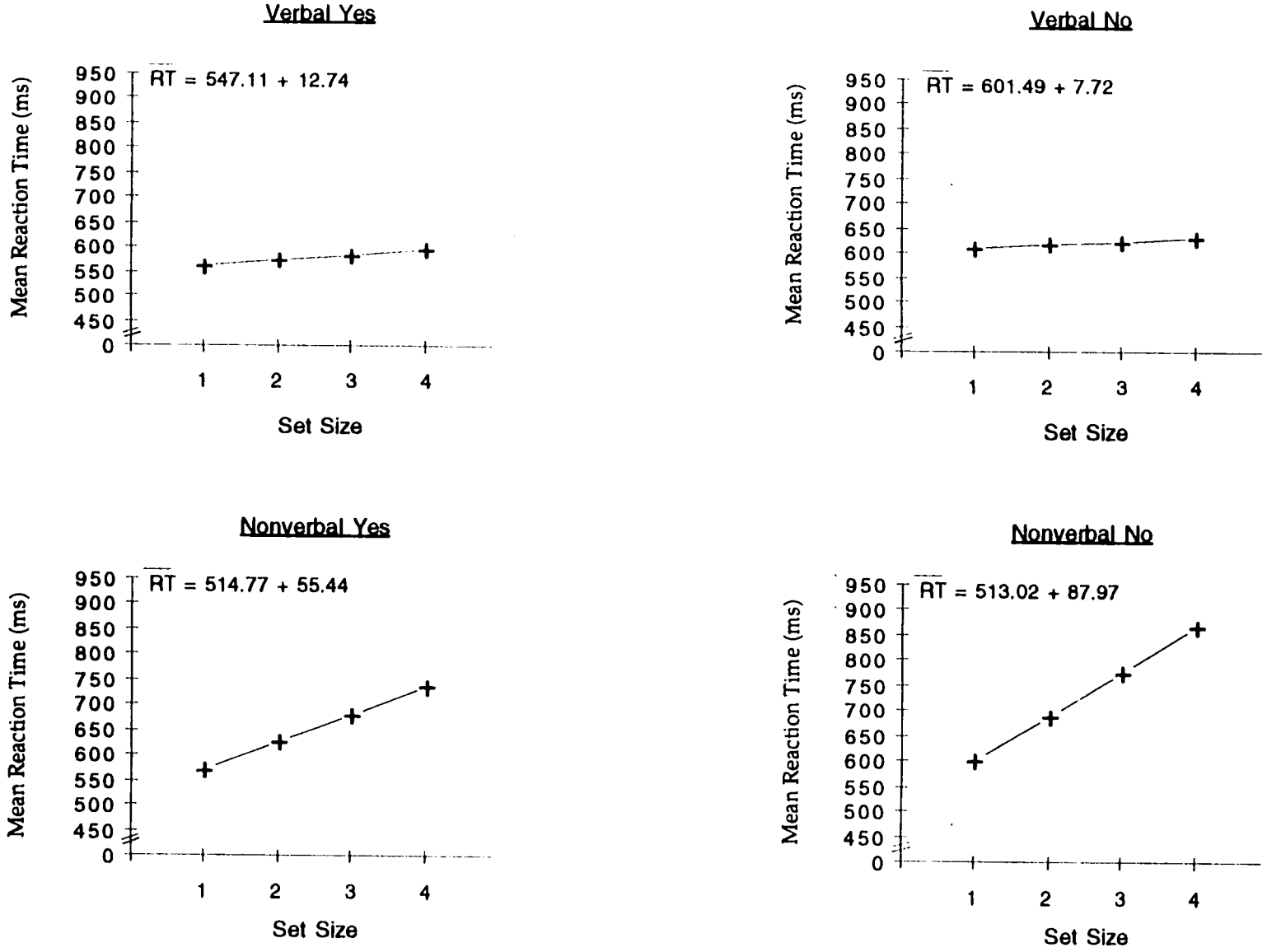




Appendix K.3. Mean Regression Line for Verbal Yes, Verbal No, Nonverbal Yes, and Nonverbal No Responses of the Nonpsychiatric Control Group (n = 20).



Appendix K.4. Mean Regression Line for Verbal Yes, Verbal No, Nonverbal Yes, and Nonverbal No Responses of the Nonschizotypal Relative Group (n = 20).



Appendix K.5. Mean Regression Line for Verbal Yes, Verbal No, Nonverbal Yes, Nonverbal No Responses of the Schizotypal Relative Group (n = 17).

Appendix L

Analysis of Variance for Memory Scanning Rate (Slope) Data

Source of Variance	SS	df	MS	F	p
Group (A)	34510.91	4	8627.73	1.75	.146
Error	478812.17	97	4936.21		
Stimulus Type (B)	99813.44	1	99813.44	24.01	.001
A X B	52417.11	4	13104.28	3.15	.018
Error	403289.24	97	4157.62		
Response Type (C)	66044.51	1	66044.51	44.37	.001
A X C	15148.60	4	3787.15	2.54	.044
Error	144397.05	97	1488.63		
B X C	12247.33	1	12247.33	5.26	.024
A X B X C	7301.30	4	1825.33	.78	.538
Error	223802.31	97	2327.86		

Appendix M

Analysis of Variance for Encoding, Deciding, and Responding Time (Intercept) Data

Source of Variation	SS	df	MS	F	p
Group (A)	483503.69	4	120875.92	2.28	.066
Error	5148507.13	97	53077.39		
Stimulus Type (B)	13286.93	1	13286.93	.60	.442
A x B	182139.54	4	45534.88	2.05	.094
Error	2158032.69	97	22247.76		
Response Type (C)	10951.51	1	10951.51	1.63	.205
A X C	6758.62	4	1689.66	.25	.908
Error	652138.28	97	6723.08		
B X C	9934.26	1	9934.26	1.44	.234
A x B x C	16684.07	4	4171.02	.60	.661
Error	671070.05	97	6918.25		

Appendix N

Intraclass Correlation Coefficient Formula (Model 1, Shrout and Fleiss, 1979).

$$\sigma_A^2 = \frac{\text{MS between - MS within}}{N}$$

$$\sigma_Y^2 = \frac{\text{MS between + (N-1) MS within}}{N}$$

$$ICC = \frac{\sigma_A^2}{\sigma_Y^2}$$

Appendix O

Summary of the Analysis of Variance for Dichotic Listening Accuracy

Source of Variation	SS	df	MS	F	p
Group (A)	23970.41	4	5992.60	3.08	.020
Error	188764.73	97	1946.03		
Stimulus Type (B)	22209.62	1	22209.62	20.38	.001
A X B	4660.66	4	1165.17	1.07	.376
Error	105700.86	97	1089.70		
Ear (C)	1896.24	1	1896.24	1.15	.287
A X C	20022.76	4	5005.69	3.02	.021
Error	160542.12	97	1655.07		
Block (D)	2081.43	3	693.81	2.50	.060
A X D	2856.38	12	238.03	.86	.592
Error	80862.98	291	277.88		
B X C	1045.40	1	1045.40	.86	.355
A X B X C	29658.40	4	7414.60	6.13	.001
Error	117324.21	97	1209.53		
B X D	749.80	3	249.93	.86	.462
A X B X D	3000.68	12	250.06	.86	.587
Error	84455.66	291	290.23		
C X D	2608.59	3	869.53	4.34	.005
A X C X D	1851.67	12	154.31	.77	.680
Error	103715.38	582	178.21		
B X C X D	1197.94	3	399.31	2.30	.078
A X B X C X D	1655.05	12	137.92	.79	.657
Error	50569.59	291	173.78		

Appendix P

Summary of the Analysis of Variance for Dichotic Listening Reaction Time for Correct Responses

Source of Variation	SS	df	MS	F	p
Group (A)	26274998.38	4	6568749.6	4.54	.002
Error	121596081.9	84	1447572.4		
Stimulus Type (B)	2162717.35	1	2162717.4	7.79	.007
A X B	1482908.65	4	370727.16	1.33	.264
Error	23335349.89	84	277801.78		
Ear (C)	6831.16	1	6831.16	.08	.780
A X C	226125.90	4	56531.47	.65	.630
Error	7322653.57	84	87174.45		
Block (D)	960972.27	3	320324.09	5.67	.001
A X D	416350.47	12	34695.87	.61	.830
Error	14237050.61	252	56495.23		
B X C	5808.67	1	5808.67	.08	.785
A X B X C	699368.00	4	174842.00	2.26	.069
Error	6488016.78	84	77238.30		
B X D	289831.97	3	96610.66	2.11	.100
A X B X D	775562.90	12	64630.24	1.41	.162
Error	11562538.01	252	45883.09		
C X D	33655.62	3	11218.54	.36	.784
A X C X D	439862.13	12	36655.18	1.17	.307
Error	7912063.82	252	31397.08		
B X C X D	152731.73	3	50910.58	1.83	.142
A X B X C X D	163757.27	12	13646.44	.49	.919
Error	7007934.89	252	27809.27		

Appendix Q

Summary of the Analysis of Variance for Dichoptic Viewing Accuracy

Source of Variation	SS	df	MS	F	p
Group (A)	15815.40	4	3953.87	1.30	.276
Error	295517.72	97	3046.57		
Stimulus Type (B)	164292.00	1	164292.00	142.66	.001
A X B	4573.48	4	1143.37	.99	.415
Error	111709.17	97	1151.64		
Visual Field (C)	10329.67	1	10329.67	11.24	.001
A X C	2601.44	4	650.36	.71	.588
Error	89119.32	97	918.76		
Block (D)	3954.59	3	1315.20	3.82	.010
A X D	3586.90	12	298.91	.87	.579
Error	100127.00	291	344.08		
B X C	56.21	1	56.21	.07	.793
A X B X C	4880.73	4	1220.18	1.50	.207
Error	78702.00	97	811.36		
B X D	173.86	3	57.95	.21	.892
A X B X D	3084.57	12	257.05	.91	.534
Error	81942.14	291	281.59		
C X D	1891.86	3	630.62	2.70	.046
A X C X D	3645.46	12	303.79	1.30	.218
Error	68009.62	291	233.71		
B X C X D	299.20	3	99.73	.45	.715
A X B X C X D	2663.19	12	221.93	1.01	.441
Error	64029.42	291	220.03		

Appendix R

Summary of the Analysis of Variance of Dichoptic Viewing Reaction Times for Correct Responses

Source of	SS	df	MS	F	p
Group (A)	10903876.36	4	2725969.10	4.48	.002
Error	51742919.70	85	608740.23		
Stimulus Type (B)	2362312.28	1	2362312.30	10.48	.002
A X B	115972.58	4	28993.14	.13	.972
Error	19159886.66	85	225410.43		
Visual Field (C)	309831.49	1	309831.49	6.65	.012
A X C	189205.37	4	47301.34	1.01	.405
Error	3962974.08	85	46623.22		
Block (D)	880013.82	3	293337.94	9.87	.001
A X D	259348.42	12	21612.37	.73	.725
Error	7582041.34	255	29733.50		
B X C	60785.74	1	60785.74	1.69	.198
A X B X C	86036.64	4	21509.16	.60	.666
Error	3066264.58	85	36073.70		
B X D	160914.65	3	53638.22	2.05	.108
A X B X D	146128.49	12	12177.37	.47	.934
Error	6676837.15	255	26183.68		
C X D	230670.28	3	76890.09	4.35	.005
A X C X D	142248.18	12	11854.01	.67	.778
Error	4503244.08	255	17659.78		
B X C X D	8326.49	3	2775.50	.15	.929
A X B X C X D	132940.16	12	11078.35	.61	.837
Error	4666813.84	255	18301.23		

Appendix S

Summary of the Analysis of Variance for Auditory Discrimination Accuracy

Source of Variation	SS	df	MS	F	p
Group (A)	10418.67	4	2604.67	3.20	.016
Error	78872.31	97	813.12		
Stimulus Type (B)	10024.95	1	10024.95	19.83	.001
A X B	4979.89	4	1244.97	2.46	.050
Error	49028.85	97	505.45		
Block (D)	716.93	3	238.98	1.50	.215
A X D	2050.59	12	170.88	1.07	.383
Error	46378.05	291	159.37		
B X D	246.90	3	82.30	.41	.746
A X B X D	2819.11	12	234.93	1.17	.303
Error	58333.57	291	200.46		

Appendix T

Summary of the Analysis of Variance of Auditory Discrimination Reaction Times for Correct Responses

Source of Variation	SS	df	MS	F	p
Group (A)	23047982.34	4	5761995.60	9.53	.001
Error	56851416.70	94	604802.31		
Stimulus Type (B)	656516.78	1	656516.78	3.82	.054
A X B	759979.79	4	189994.95	1.11	.358
Error	16139631.93	94	171698.21		
Block (D)	551013.47	3	183671.16	7.27	.001
A X D	595674.74	12	49639.56	1.97	.027
Error	7123622.28	282	25261.07		
B X D	90059.15	3	30019.72	1.13	.335
A X B X D	180760.72	12	15063.39	.57	.866
Error	7460745.49	282	26456.54		

Appendix U

Summary of the Analysis of Variance for Visual Discrimination Accuracy

Source of Variation	SS	df	MS	F	p
Group (A)	12010.34	4	3002.59	3.06	.020
Error	95310.43	97	982.58		
Stimulus Type (B)	133123.67	1	133123.67	244.60	.001
A X B	1846.24	4	461.56	.85	.498
Error	52791.66	97	544.24		
Block (D)	2037.95	3	679.32	5.56	.001
A X D	1194.75	12	99.56	.82	.635
Error	35547.74	291	122.16		
B X D	451.57	3	150.52	1.61	.188
A X B X D	2067.42	12	172.28	1.84	.042
Error	27268.33	291	93.71		

Appendix V

Summary of the Analysis of Variance of Visual Discrimination Reaction Times for Correct Responses

Source of	SS	df	MS	F	p
Group (A)	6835667.9	4	1708917.0	8.31	.001
Error	19740174.44	96	205626.82		
Stimulus Type (B)	4259373.46	1	4259373.5	38.03	.001
A X B	157779.88	4	39444.97	.35	.842
Error	10751612.16	96	111995.96		
Block (D)	963883.46	3	321294.49	21.77	.001
A X D	176429.35	12	14702.45	1.00	.453
Error	4250765.82	288	14759.60		
B X D	15854.36	3	5284.79	.38	.768
A X B X D	74086.37	12	6173.86	.44	.945
Error	4012861.27	288	13933.55		

Appendix W

Ratios of Positive and Negative Slopes for Each Group for Verbal and Nonverbal Stimulus Type.

Group	Verbal Ratio	Nonverbal Ratio
Schizophrenia	1:2.28	1:2.06
Schizotypal Relative	1:0.61	1:1.59
Nonschizotypal Relative	1:1.71	1:2.11
Nonpsychiatric Control	1:1.84	1:1.61
Psychiatric Control	1:1.46	1:2.09