COGNITIVE FUNCTIONING IN ANXIETY AND DEPRESSION IN SCHIZOPHRENIA

Helen M. Griffiths

Doctorate of Clinical Psychology

The University of Edinburgh

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This thesis has been completed by myself and the work contained herein is my own

Helen M. Griffiths

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LIST OF ABBREVIATIONS

AKS = Alcoholic Korsakoff Syndrome

BFS = Befindlichskeitskala

BIS = Behavioural Inhibition System

Chron = Chronicity of illness in years

CT = Computerised tomography

CVLT = California Verbal Learning Test

CVLT1-5 = Sum of trials 1 - 5 of the California Verbal Learning Test

CVLTDelay = Delayed recall trial of the California Verbal Learning Test

CVLTRecog = Recognition trial of the California Verbal Learning Test

DepCat = Deprivation category

DLPFC = Dorsolateral prefrontal cortex

DSM = Diagnostic and Statistical Manual of Mental Disorders

ECT = Electroconvulsive therapy

EEG = Electroencephalography

FAS = Controlled Word Association Test

Ktotal = Total score on Krawiecka Psychiatric Assessment Scale

L.I. = Latent inhibition

MANOVA = Multivariate analysis of variance

Meds 1 = Chloropromazine equivalents of antipsychotic medication

Meds 2 = Presence or absence of anticholinergic medication

MMPI = Minnesota Multiphasic Personality Inventory

Orient(ation) = Orientation subscale of the Rivermead Behavioural Memory Scale

PANSS = Positive and Negative Symptom Scale

PET = Positron emission tomography

P.I. = Proactive interference

RBMT = Rivermead Behavioural Memory Test

rCBF = Regional cerebral blood flow

S.D. = Standard deviation

SES = Socio-economic status

Speed of Comp/SOCT = Speed of Comprehension Test

S-SAI = Spielberger State Anxiety Inventory

TrailsA = Trail Making Test Part A

TrailsB = Trail Making Test Part B

TrailsB-A = Time taken on TrailsB minus the time taken on TrailsA

WAIS = Weschler Adult Intelligence Scale

WCST = Wisconsin Card Sorting Test

WISC-R = Weschler Intelligence Scale for Children - Revised

ABSTRACT

Deficits in memory and impairments in executive function have been observed in patients suffering from schizophrenia in several studies (e.g. McKenna, Tamlyn, Lund, Mortimer, Hammond and Baddeley, 1990; Kolb and Wishaw, 1983). Typically, the degree of these impairments has not been found to be attributable to psychotic medication, nor to poor motivation or co-operation. On the other hand, other factors, including age and educational background, have been found to influence neuropsychological test performance. The presence of anxiety, and particularly depression, is now widely acknowledged to exist within the schizophrenic disease process. Depression is also associated with neuropsychological impairments in memory and executive function, with the level of impairment tending to vary with the severity of depression (e.g. Austin, Ross, Murray, O'Carroll, Ebmeier and Goodwin, 1992). There is less evidence linking anxiety with impaired performance on neuropsychological tests. However, the main hypothesis is that anxious subjects may experience a diminution of attention to external stimuli. The present study tests the hypothesis that some of the apparent cognitive deficits associated with schizophrenia are accounted for by elevated levels of anxiety and depression. A secondary hypothesis is that these cognitive deficits are specific rather than generalised. Finally, following the proposals of Liddle (1987), the study explores the relationships between cognitive functioning and schizophrenic symptomatology. A heterogeneous sample of 40 patients meeting DSM-IV criteria for schizophrenia was compared to a healthy control group on measures of memory, executive functioning and mood state. The results are discussed with reference to recent neuropsychological models of schizophrenia.

1.0 INTRODUCTION

Neuropsychological test performance is known to be influenced by many variables including, for example, age and educational background (Lezak, 1995). It has also been suggested that emotional factors, particularly depression, might have a potential impact on the test performance of patients with psychiatric disorders (e.g. Gass and Russell, 1986; Heaton and Crowley, 1981). Indeed, whilst psychologists are often required to differentiate between organic and functional impairments, a not infrequent conclusion is that test performance may have been affected by test anxiety or by depressed mood. Clinical observations such as these are yet to be supported empirically, as there is surprisingly little research in this field. To add further confusion, the boundary between 'functional' and 'organic' has become somewhat blurred, and recent research has highlighted the cognitive impairments that may accompany depression, schizophrenia and other disorders.

Research into the neuropsychology of psychosis has taken place at varying clinical levels of analysis (O'Carroll, 1992). Strategies have included focusing on a disorder/illness, on specific syndromes (e.g. Liddle, 1987) (see section 1.5) or, more recently, on symptoms of psychotic illness (Bentall, Jackson and Pilgrim, 1988) (section 1.2.3.5). Theoretical models have similarly been constructed at differing levels of analysis, from those that focus on specific aspects of particular systems to those which encompass multiple dysfunctional cognitive systems, such as Gray, Feldon, Rawlins, Hemsley and Smith (1991) and Frith (1992). Both these influential models are described in some detail in sections 1.2.1 and 1.2.2, respectively. Despite the many advances in our knowledge of

psychotic phenomena, it would appear that there is as yet little agreement as to the specific brain dysfunction(s) nor the cognitive abnormalities underlying schizophrenia.

One aspect of neuropsychological functioning in schizophrenia which has so far received little systematic study is the impact that co-existing anxiety and depression in schizophrenia might have on the level of cognitive impairment measured. This neglect has occurred despite the growing consensus that many patients with schizophrenia concurrently display symptoms of anxiety and depression (e.g. Foulds and Bedford, 1975; Johnson, 1981). The literature concerning the prevalence and measurement of affect in schizophrenia is discussed more fully in section 1.1. Furthermore, there is a significant literature that highlights the cognitive dysfunction that accompanies anxiety and particularly depression (see section 1.3). A key aim of the present research is therefore to test the hypothesis that some of the apparent cognitive deficits associated with schizophrenia are accounted for by elevated levels of anxiety and depression in patients with schizophrenia.

A separate issue which has recently generated some considerable debate is whether the cognitive impairments in schizophrenia are generalised in nature or whether they also demonstrate a disproportionate deficit specific to a particular aspect of cognitive functioning. The present study centres primarily on the impairments displayed by patients with schizophrenia in memory (see section 1.2.3) and executive functioning (section 1.2.4). The review in section 1.4 focuses more narrowly on the generalised versus disproportionate deficit debate. For example, Blanchard and Neale (1994) proposed that the neuropsychological test performance typically observed in patients with schizophrenia reflected a generalised deterioration in cognitive function (section 1.4.1). On the other

hand, as reported in section 1.4.2, the results of Saykin, Gur, Gur, Mozley, Mozley, Resnick, Kester and Stafiniak's (1991) study suggested that there was a disproportionate memory and learning deficit against a background of more generalised impairment. Other researchers, though, have demonstrated a differential deficit on tests of executive function relative to tests reflecting other aspects of cognitive functioning (e.g. Kolb and Whishaw, 1983). The second aim of the present study is therefore to explore the nature of the cognitive impairment typically observed in schizophrenia. That is, to question whether the pattern of neuropsychological test results reflect a generalised impairment or whether there is evidence of an additional disproportionate deficit specific to either learning and memory or executive function.

As outlined in section 1.5.1, Liddle's (1987) proposal that schizophrenic symptoms segregate into three main syndromes of psychomotor poverty, reality distortion and disorganisation has received considerable support in recent years (e.g. Johnstone and Frith, 1996). Furthermore, there has been preliminary evidence that each syndrome might be associated with particular patterns of neuropsychological performance (e.g. Liddle and Morris, 1991; Frith, Leary, Cahill and Johnstone, 1991b) (see section 1.5.2) as well as sites of dysfunction in the brain (section 1.5.4). The third aim of the present study is an attempt to replicate the finding that schizophrenic symptoms segregate into three main syndromes and further, to explore the relationship of these syndromes to neuropsychological performance.

Finally, this type of research is beset by methodological issues. Concerns include the use of appropriate control groups, the effects of antipsychotic and anticholinergic medication

on cognitive functioning and the lack of psychometrically matched neuropsychological tasks. These, and other methodological concerns, are addressed in section 1.6.

1.1 Affect in schizophrenia

1.1.1 Schizophrenia may not be a discrete entity

Recently, McGovern (submitted) has proposed a continuum model of psychopathology incorporating schizophrenia. In fact, the idea is not a new one (see Strauss, 1969). McGovern's model is based on a hierarchy of psychopathology with normal non-clinical conditions at one end of the continuum, varying severities of neurotic disorders such as depression, anxiety and obsessional-compulsive disorder in between, and psychotic disorders such as schizophrenia at the extreme end of the continuum. Furthermore, "most importantly, each category overlaps with every other category. Schizophrenia may or may not include depressive, anxiety, obsessive-compulsive and normal non-pathological symptoms" (McGovern, submitted, p.6).

Bentall et al (1988) has also argued against the notion of schizophrenia as a discrete entity, querying the usefulness of the schizophrenic concept on the grounds that there are problems with reliability, construct and predictive validity. With regards to reliability, the different operational criteria which have been proposed for schizophrenia tend to diagnose different patients as schizophrenic (Brockington, Kendell and Leff, 1979). Validity refers to the extent to which the concept can be said to be meaningful. The concept of schizophrenia should represent symptoms that cluster together. However, multivariate statistical techniques applied to symptom data have failed to find such a cluster

(Blashfield, 1984). Furthermore, the diagnosis of schizophrenia does not seem to be particularly helpful in predicting outcome or response to treatment. For example, Kendell (1989) reported that trials of drugs randomly assigned irrespective of diagnosis failed to reveal a diagnosis-specific pattern of drug-response. Similarly, there are reports in the literature of successful treatment of schizophrenia with lithium, usually associated with the treatment of bipolar affective disorder (Delva and Letemendia, 1982). It has therefore been concluded by at least one researcher that "schizophrenia is a disease with no particular symptoms, which follows no particular course, has no particular outcome and responds to no particular treatment" (Bentall, 1992, p. 62).

Research in other fields has also questioned the specificity of the schizophrenic diagnosis. For example, Jeste, Lohr and Goodwin's (1988) review of neuroanatomical studies of affective disorders found that in the majority of studies using computerised tomography (CT) scans, patients with either bipolar or unipolar affective disorders were similar to patients with schizophrenia and different from normal controls in terms of ventricle:brain ratio, sulcal widening and cerebellar vermian atrophy. Furthermore, Baron and Gruen (1991) found some evidence that affective disorders were associated with a genetic liability to schizophrenia. Such results appear to support the position of Freedman (1975) who proposes a general biology of psychosis.

1.1.2 Presence of neurotic symptoms in schizophrenia

Crossing further boundaries is the accumulating evidence for the presence of neurotic symptoms in schizophrenia, which provides significant support for a continuum model of psychopathology. Using the Delusions-Symptoms-State Inventory, Foulds and Bedford

(1975) found that, on this self-report questionnaire, patients who affirmed psychotic phenomena also affirmed neurotic symptoms of anxiety and depression. More is known about the prevalence of depression in schizophrenia, although estimates vary. Mandel, Severe, Schooler, Gelenberg and Mieske (1982) reported that 25% of their 211 patients suffering from schizophrenia developed depression within 5 months after hospital discharge, whilst between 25 - 50% of patients may manifest depressive features during the acute phase. Johnson's (1981) two-year longitudinal study confirmed findings that depression is a frequent symptom during relapse (60%) and maintenance therapy (50%). The same author concluded that "depression is a frequent symptom in the course of schizophrenia, likely to be present in all phases - first illness, relapse whether or not on drugs and in patients maintained in remission on regular depot neuroleptic injections" (p.89). More recently, these results have been confirmed with epidemiological studies reporting that 40 - 50% of patients with schizophrenia have a mild to moderate depressive illness, and 5 - 10% have more severe clinically significant depression (e.g. Markou et al, 1996).

Diagnostic criteria use the categorisation of schizoaffective disorder for the psychiatric condition marked by the expression of symptoms of both schizophrenia and affective illness. It should therefore be emphasised that the prevalence of neurotic symptoms described in the above paragraph relate to patients who have been given a diagnosis of schizophrenia as opposed to the more general diagnosis of schizophrenia-related disorder. Although there is little information regarding its actual prevalence, schizoaffective disorder is generally considered to be rarer than schizophrenia. The World Health Organisation (WHO) 10-country study reported that with a broad definition of schizophrenia, rates ranged from between 1.5 to 4.2 per 100,000 of the populations. A

narrower definition, based on the presence of Schneiderian first-rank symptoms, gave an incidence of 0.7 to 1.4 per 100,000 of the populations (Jablensky, Sartorius, Ernberg, Anker, Korten, Cooper, Day and Bertelsen, 1992). Given the prevalence of neurotic symptoms in schizophrenia, it would seem debatable whether schizophrenia and so-called schizophrenia-related disorders can really be conceptualised as distinct entities. It would appear more likely that there is a continuum of psychopathology as proposed in section 1.1.1, with schizophrenia-related illnesses such as schizoaffective disorder occurring some way between schizophrenia and affective illness.

Scales developed for the assessment of schizophrenia, such as the Positive and Negative Symptoms Scale - PANSS (Kay, Fishbein and Opler, 1987), acknowledge the presence of an affective component by including subscales for anxiety and depression. Finally, Roger et al's (1996) test of Liddle's (1987a) proposition that schizophrenic symptoms may be divided into 3 syndromes of psychomotor poverty, disorganisation and reality distortion found that a fourth, affective, factor was also distinguishable. This study is discussed in more detail in section 1.5.3. Thus, there is considerable support from a variety of sources that schizophrenia may include symptoms of anxiety and depression.

An interesting dichotomy exists in the psychological literature. Whereas research into anxiety and depression has tended to focus on cognitive *biases*, much energy has been expended in an attempt to identify the cognitive *dysfunction(s)* that may underlie schizophrenia. More recently, there has been a subtle shift in the literature. Studies of the cognitive biases in the thinking of psychotic patients are emerging, whilst conversely, a neuropsychology of depression, and to a lesser extent of anxiety, is developing. Although there is now preliminary research into the cognitive biases present in schizophrenia (see

section 1.2.3.5), the current discussion will primarily limit itself to a review of cognitive impairments, in schizophrenia (sections 1.2.3 and 1.2.4) and also in depression and anxiety (section 1.3).

1.2 The neuropsychology of schizophrenia

As long ago as 1919, Kraepelin noted that schizophrenic "behaviour is without a doubt nearly related to the disorder of attention which we very frequently find conspicuously developed in our patients". Nearly eighty years later on, the exact nature of this cognitive deficit remains unknown, at either the neuroanatomical or the neuropsychological level of analysis. Some authors have suggested a generalised neuropathology, e.g. Meehl (1990), whilst others claim a hemispheric effect. For example, the left hemisphere is favoured by Crow (1990) amongst others, whilst Cutting (1985) and Mayer, Alpert, Stastny, Perlick and Empfield (1985) propose the right hemisphere as the locality of dysfunction. Alternatively, a number of discrete neuroanatomical regions have been implicated in schizophrenia. Weinberger (1987), for one, supports a frontality hypothesis, whilst having conducted an extensive review of the literature, Buschbaum (1990) concludes that the frontal lobes, the basal ganglia and the temporal lobes all have a role in the neuropsychology of this disorder. It is clear that there is still little consensus as to the localisation of brain dysfunction(s) in schizophrenia.

At the neuropsychological level of explanation, there is similarly a profusion of research findings implicating impairment of different aspects of cognitive functioning in schizophrenia. For the purposes of the present study, the literature review will be restricted primarily to two main areas of cognitive functioning which various researchers

have observed to be impaired in patients with schizophrenia; namely, impairments in memory and learning (section 1.2.3) and deficits in executive function (section 1.2.4). Before these specific impairments are discussed, however, an overview of two influential models of schizophrenia is given. Both these theories (Gray et al, 1991; Frith, 1992) are accounts of the cognitive neuropsychology of schizophrenia, although both also attempt to map their proposed models onto known systems of brain function.

1.2.1 Schizophrenia and the integrative function of memory in current perception: Gray et al's (1991) model

Gray et al's (1991) ambitious model of schizophrenic dysfunction attempts to integrate neural and cognitive aspects of schizophrenia, drawing upon evidence from many scientific disciplines including neurobiology, neuroanatomy, neuropsychology and cognitive psychology. The model is based upon two hypotheses. First of all, Hemsley's (1987a) proposal that "it is a weakening of the influences of stored memories of regularities of previous input on current perception which is basic to the schizophrenic condition" (cited in Gray et al, 1991, p.2) was supported by evidence relating to the effects of amphetamine and neuroleptics on latent inhibition (L.I.) and the Kamin blocking effect. Both these paradigms demonstrate that pre-exposure to a stimulus impairs subsequent learning. A third paradigm, proactive interference (P.I.), occurs when new learning is diminished as a consequence of previously learned material. O'Carroll, Murray, Austin, Ebmeier, Goodwin and Dunan (1993) used P.I. to further test the hypothesis that the basic phenomenon of acute schizophrenia is a weakening of the influence of memories of previous input on current perception. On the basis of Gray et al's (1991) model, it was predicted that acutely ill unmedicated patients with schizophrenia would demonstrate

reduced P.I. relative to controls. Contrary to the hypothesis, O'Carroll et al (1993) found that there were no significant differences between acutely ill schizophrenic patients, depressed subjects and healthy controls. Investigating why the different paradigms of latent inhibition and proactive interference produced differing results, O'Carroll (1995) pointed out that L.I. clearly involved associative learning whilst P.I. did not. He predicted that "if schizophrenia is characterised by a weakening of the effects of previous experience on new learning, then acutely ill deluded patients would demonstrate a weakening of the interfering effects of recently learned associations when attempting to establish new associations, and should therefore perform *better* than recovered patients" (p. 300). In contrast, O'Carroll (1995) found that acutely deluded patients were *more* impaired on the associative learning task than matched recovered patients. There is thus so far only limited support in favour of Hemsley's (1987a) hypothesis.

The second hypothesis which Gray et al (1991) adopted was Frith's (1987) proposition that "willed intentions are not monitored correctly" in schizophrenia. This shall be discussed in the following section (section 1.2.2). Taking the two hypotheses together, the main tenet of Gray et al's theoretical construct is to give emphasis to "a failure in acute schizophrenia to integrate stored memories of past regularities of perceptual input with ongoing motor programmes in the control of current perception" (p.1). The model also speculates about the neural dysfunction(s) implicated in schizophrenia, emphasising the projections from the septohippocampal system, via the subiculum and the amygdala to the nucleus accumbens, and their interaction with the ascending dopaminergic projection to the accumbens. Positive schizophrenic symptoms, Gray et al suggest, arise from a disruption in the normal functioning of the input to the basal ganglia from the limbic system.

The model of schizophrenia is an extension of a previous attempt to provide a neuropsychological account of anxiety. Gray's (1982) theory of anxiety postulates the existence of a behavioural inhibition system (BIS) whose principal role is to compare actual environmental cues to expected stimuli. If the perceived stimuli are aversive or novel, then the BIS is activated. Thus, the basic activity of the system constitutes anxiety, a central state elicited by threats of punishment, frustration or failure and by novelty and associated uncertainty. When the BIS is activated, the execution of the ongoing motor program is inhibited and engages in a number of alternative steps. Gray (1982) suggests that the BIS has its neuronal basis in the septohippocampal system and interconnected structures such as the temporal lobes and prefrontal cortex. Whilst the anxiety model focuses on the information-processing system's attempts to detect and respond to a mismatch between actual and predicted states of the world, the model of schizophrenia concerns itself with the monitoring process itself and how this process interacts with the running of motor programs. That is, the model of anxiety hypothesises that, if there is a mismatch, the current motor program is halted so that additional information can be assimilated in order for problem-solving to take place. The model of schizophrenia postulates a dysfunction in the internal monitoring process and its interaction with the running of those motor programs. If anxiety co-exists with schizophrenia, there does not appear to be a theoretical reason why there could not be dysfunctions occurring at both stages of the BIS concurrently.

Gray et al's (1991) theoretical paper was followed by a number of critical comments. These included, among many others, the observation that the model failed to capture the essential nature of psychosis, the limitation of the model to acute symptoms with scant attention paid to the problems posed by chronic schizophrenia, and a failure to

acknowledge the importance of the intellectual impairments often observed in schizophrenia. Despite such objections, the model was generally well received. A clear advantage was the number of testable hypotheses generated, though as described above (O'Carroll et al, 1993; O'Carroll, 1995) these hypotheses have not received unequivocal support

1.2.2 Schizophrenia as a disorder of self-awareness: Frith's (1992) model

Whilst Gray et al (1991) proposed that schizophrenia was a disorder of the integration of memory on current perception, Frith (1992) suggested that the underlying problem was one of a disorder of self-awareness. As previously stated in section 1.2.1, Frith (1987) proposed that willed intentions are incorrectly monitored in schizophrenia. Positive symptoms such as thought insertion, auditory hallucinations and experiences of alien control were said to arise as a consequence of problems with the internal monitoring of responses. Frith (1987) hypothesised that many of the positive symptoms of acute schizophrenia could be explained by an inability to label self-generated thoughts and/or actions as 'my own'. Thus, the patient subsequently experiences himself carrying out acts without the simultaneous awareness of intending to perform such acts. This results in the symptom referred to as delusion of control. Frith proposes that the same defect in the internal monitoring of thoughts, the ability to switch attention and subvocal speech (or to think) results in the experiencing of thought insertion, delusions of reference and thought broadcasting or auditory hallucinations, respectively. In support of the hypothesis that there is a defect in the central monitoring of responses, Frith and Done (1989) found that a subgroup of schizophrenic patients who had experiences of alien control of thoughts and

actions were significantly poorer at correcting errors in internal monitoring than were other psychotic patients or normal controls.

Furthermore, Frith and Done (1988) proposed a link between positive symptoms, the faulty monitoring system and a number of brain systems which may be involved in this psychological mechanism. The psychological model invokes the concept of two routes to action (Goldberg, 1985; Passingham, 1987). These are, firstly, the route of self-generated or spontaneous action and secondly, stimulus-driven action. Frith and Done (1988) suggest that a major function of the internal monitor is to distinguish between these two routes to action. It is commonly held that planning and goal-directed behaviour are essential functions of the prefrontal cortex (e.g. Luria, 1983). It has been suggested (e.g. Goldberg, 1985) that damage at any point between the prefrontal cortex and motor cortex would lead to problems for self-generated responses. Whilst Gray's (1982) 'comparator', located in the septo-hippocampal system as outlined previously in section 1.2.1, corresponds closely to the monitoring system proposed by Frith and Done (1988), the former does not distinguish between stimulus-driven and willed-intention responses.

In his latest model, Frith (1992) expands on these previous theories to provide a cognitive neuropsychological explanation of all the major signs and symptoms of schizophrenia, proposing that the underlying cognitive abnormality was one of a disorder of self-awareness. 'Metarepresentation', Frith maintains, is the cognitive process fundamental to conscious experience, crucial for the occurrence of self-awareness. To be self-aware, one must not only be able to experience the content of physical or mental occurrences but also be able to metarepresent those experiences or, in other words, to have knowledge of *how* that experience is represented. Metarepresentation (e.g. "I am doing X") anchors the event

as being part of the individual's conscious experience. If there is a failure in this mechanism of self-consciousness, then one only has the experiential content ("X") and not the knowledge of how that knowledge is represented in the world. If a person has a difficulty with metarepresentation, then they will therefore have problems describing their inner experiences.

With respect to schizophrenia, Frith (1992) proposes that this general, underlying cognitive abnormality in metarepresentation might give rise to three pathways of symptom expression. First of all, disorders of willed action may lead to the expression of negative symptoms such as poverty of movement, speech or affect. Patients suffering from such symptoms, it is proposed, have problems in carrying out spontaneous behaviour in the absence of environmental stimuli. However, it is also suggested that the positive symptoms of incoherent speech and behaviour arise because of this problem in willed action. In these cases, not only is there a difficulty in generating intentional action but there is also a failure to suppress inappropriate behaviour in the absence of external cues. This leads to behaviours such as perseveration and responses to irrelevant stimuli. Secondly, as described in the paragraph above, Frith hypothesises that positive symptoms such as thought insertion, delusions of alien control and certain auditory hallucinations may be attributed to a disorder of an internal monitoring system which fails to distinguish between self-generated and stimulus-driven action. Thirdly, other core symptoms may be caused by a disorder in the monitoring of the intentions of others. For example, patients with paranoid delusions believe incorrectly that others are intending them harm, whilst patients with delusions of reference believe incorrectly that other people are attempting to communicate with them. Frith also argues that certain kinds of incoherent speech occur because patients may fail to infer what information the other person requires in order to

understand the patient's speech. This attempt to link clinical symptoms with predicted patterns of behaviour paves the way for future research.

As yet there is little evidence which would allow the proposed psychological model to be mapped onto specific brain systems. It is interesting, though, that the class of symptoms referred to by Frith as 'behavioural abnormalities' (poverty of action, perseveration and behaviour elicited by irrelevant external stimuli) resemble the behaviours frequently observed in patients with frontal lobe lesions. An intriguing study by McGuire, Silbersweig, Wright, Murray, Frackowiak and Frith (1996) does, however, use a novel paradigm in an attempt to further understanding of the pathophysiology of a specific symptom of schizophrenia. The study compared a group of patients who habitually heard auditory hallucinations to a group of patients who, unusually, never or seldomly heard auditory hallucinations using positron emission tomography. It was found that, when asked to imagine words spoken in another person's voice, normal subjects and non-hallucinator patients showed strong activation in the region of the left middle temporal gyrus. Compared to both control groups, patients who hallucinated demonstrated reduced activation of the same region. McGuire et al (1996) argued that this was consistent with a failure to activate a monitoring system responsible for indicating to the person that what they are perceiving is self-generated.

In summary, both Gray et al's (1991) and Frith's (1992) models provide comprehensive accounts of the cognitive neuropsychology of schizophrenia. Both offer testable hypotheses about the nature of the disorder of schizophrenia which will no doubt guide research in schizophrenia for years to come. In particular, both models make predictions about the nature of the cognitive deficits associated with schizophrenia, and suggest how

these impairments might be related to schizophrenic psychopathology. Impairments in memory and executive functioning have frequently been implicated. The following sections therefore review the literature pertaining to the impairments in both learning and memory (section 1.2.3) and executive function (section 1.2.4) which have been observed in patients suffering from schizophrenia.

1.2.3 Memory impairments in schizophrenia

Despite Cutting's (1990) conclusion that there was no evidence whatsoever for the existence of an amnesic syndrome in schizophrenia, two studies within the next twenty-four months (McKenna et al, 1990; Saykin et al, 1991), as well as several pieces of research since, suggested otherwise. McKenna et al's (1990) heterogeneous schizophrenic sample were found to have a disproportionate memory versus cognitive impairment. Using the same schizophrenic sample, Tamlyn, McKenna, Mortimer, Lund, Hammond and Baddeley (1992) concluded that the pattern of memory deficit (preserved intelligence and short-term memory with marked deficits in episodic long-term memory) resembled that observed in classic amnesic syndrome. This more detailed neuropsychological analysis also demonstrated marked deficits in semantic memory, which is generally maintained to be relatively preserved in the classic amnesic syndrome (e.g. Baddeley, 1982). In a direct comparison of a schizophrenic sample with patients suffering from Alcoholic Korsakoff Syndrome (AKS), Duffy and O'Carroll (1994) replicated the results of the above studies. The results also suggested a double-dissociation between the two subject samples. The schizophrenic group demonstrated superior episodic memory functioning as tested by the Rivermead Behavioural Memory Test whilst the AKS sample performed significantly better on the Silly Sentences Test, a measure of semantic memory.

1.2.3.1 Medication and memory impairments in schizophrenia

It is possible, of course, that such results may be attributable to the effects of psychotropic medication. However, Saykin et al (1991) assessed a schizophrenic sample who had been free from neuroleptic drugs and all other medications at the time of testing for a period ranging from 2 weeks to 10 weeks. They compared their unmedicated subjects to well-matched normal controls, and found that the patients showed a generalised impairment relative to controls with a selective deficit in memory and learning as opposed to other functions.

It could be argued that the medication exerted a long-term effect which existed beyond the wash-out period or that, alternatively, long term medication has an irreversible effect on cognitive function. Accordingly, Saykin, Shtasel, Gur, Kester, Mozley, Stafiniak and Gur (1994) repeated the study, comparing a group of 37 first-episode neuroleptic-naive patients to 65 unmedicated, previously treated patients and a healthy control group. The results demonstrated that the two patient groups had nearly identical profiles showing generalised impairment relative to controls. Verbal learning and memory in both patient groups was disproportionately impaired compared to other functions, as were visual-motor processing and attention to a lesser extent. The results of this study strongly suggest that although medications may contribute to memory impairments in patients with schizophrenia, they do not explain the bulk of the deficits. The effect of medication on cognitive functioning is discussed more fully in section 1.6.1.

1.2.3.2 Memory and brain localisation

Studies of patients with known lesions suggest that the brain regions which appear to be involved in memory include the hippocampus and related structures such as the mamillary bodies, the anterior thalamic nuclei and the prefrontal cortex, areas which have collectively become known as the "septo-hippocampal system" (Swanson, 1978). Whilst it is hazardous to suggest that deficits on particular neuropsychological tests reflect specific neuropathology in schizophrenic patients, it is of interest that some neuroimaging and post-mortem anatomic studies suggest that these areas may be compromised in schizophrenia (e.g. Shelton and Weinberger, 1987; Weinberger and Berman, 1988).

1.2.3.3 Memory impairments and schizophrenic symptoms

Even less clear is how deficits in memory may be related to clinical descriptions of schizophrenia. The pattern of memory impairments observed in patients with schizophrenia appears to indicate preserved short-term memory, with impaired episodic recall (immediate and delayed) and impaired semantic memory. One interesting question is whether memory dysfunction is related to the presence of positive symptoms or whether it is independent of current psychopathology. Goldberg, Greenberg, Griffin, Gold, Kleinman, Pickar, Schulz and Weinberger (1993) found that memory was affected relatively independently of presence or severity of symptoms, and concluded that cognitive dysfunction was not simply due to 'interference' caused by positive symptoms. In support of Tamlyn et al (1992) who contended that memory impairment represents an index of deterioration, Duffy and O'Carroll (1994) found that the most significant correlate of impaired memory was chronicity of illness. As these authors pointed out, however, the

results of several studies have found that poor memory can exist in relative isolation and is not simply confined to chronic patients.

1.2.3.4 Memory impairments and delusions

A speculative attempt to relate memory dysfunction to clinical phenomenology has been made by McKenna (1987, 1991). He suggests first of all that delusions represent a dysfunction in the brain structures implicated in memory. Following Gray et al (1991), whose model is discussed in detail in section 1.2.1, McKenna (1991) proposes the septo-hippocampal as the site implicated in the formation and retention of delusions. To briefly summarise, Gray et al (1991) hypothesised that the septo-hippocampal system acts as a comparator which inhibits behaviour when actual events do not match expected events. It is also suggested that 'important' stimuli are labelled and are subjected to particular scrutiny. McKenna (1991) suggests that delusions might arise as the consequence of several system errors. First of all, neutral stimuli might be erroneously identified as important. Secondly, it is possible that there is a tendency for actual data to be erroneously judged as matching expected data when they did not do so. Thirdly, the erroneous information subsequently stored might then alter stored regularities used to make future predictions. Finally, plans of motor behaviour might be elaborated even though inappropriate for the current environment.

Furthermore, McKenna (1991) suggests that delusions arise as a dysfunction of systems involved in memory. Assuming that both memory and delusions may be equated with knowledge, he hypothesises that "delusions consist of an inappropriate laying down of new semantic memories" (p.39). As yet, the evidence linking delusions and impaired semantic

memory is weak, and there is little evidence in support of this hypothesis. Tamlyn et al (1992) found that not only were schizophrenic subjects semantically slowed but also made an increased number of semantic errors. However, the same researchers also found that the only association between memory dysfunction and symptomatology was of memory impairment with negative symptoms and thought disorder. Despite the lack of evidence, it is of note that a number of influential theoretical accounts have all invoked something very similar to abnormal knowledge as fundamental to the psychopathology of schizophrenia. These include a weakening of the influences of stored regularities (e.g. Hemsley, 1987; Gray et al, 1991) (section 1.2.1) and Frith's (1992) notion of schizophrenia as a disorder of self-awareness (section 1.2.2). This is clearly an area which merits further research, and it is suggested that a starting point would be to examine whether impairments of semantic memory are exclusive to deluded patients rather than a heterogeneous schizophrenic sample.

1.2.3.5 Delusions and reasoning biases

Bentall and his colleagues approach the problem of providing a theoretical model of delusions from a somewhat different aspect. Before this literature is reviewed, it is necessary to attempt to distinguish what is meant by cognitive *impairment* and cognitive *bias*. The term impairment is generally used in the literature to imply a deficit in one or more cognitive abilities, which may be measured by observing a subject's performance on neuropsychological tasks. Cognitive bias generally refers to selective information-processing of certain types of environmental stimuli. For example, anxious subjects may demonstrate selective processing of threatening stimuli.

Gray et al (1991) consider seven different views on the nature of schizophrenic cognitive impairment. These include:

1. "The basic cognitive defect...is an awareness of automatic processes which are normally carried out below the level of consciousness" (Frith 1979, p.233).
2. Patients with schizophrenia "concentrate on detail, at the expense of theme" (Cutting 1985, p.300).
3. Patients with schizophrenia show "some deficiency in perceptual schema formation, in automaticity, or in the holistic stage of processing" (Knight 1984, p.120).
4. Patients with schizophrenia show a "failure of attentional focusing to respond to stimulus redundancy" (Maher 1983, p.19).

(cited from Gray et al 1991, p. 3)

Whilst examples 3 and 4 specifically refer to deficiency or failure in cognitive processing, examples 1 and 2 define the schizophrenic cognitive impairment as awareness of processes or stimuli of which normal subjects are unaware. A shift in awareness to alternative stimuli would appear more akin to what is generally referred to as cognitive bias. It would seem as though this bias/impairment distinction requires further conceptual analysis. For example, does a cognitive bias in one part of the information-processing system imply a cognitive impairment elsewhere? This, however, is beyond the bounds of the current discussion. For present purposes, bias and impairment will be used as outlined in the simple definitions in the above paragraph. That is, 'bias' is used to refer to the selective processing of certain types of stimuli. 'Impairment' is used to refer to a deficit in a cognitive ability.

Maher (1974) had proposed that delusions should be regarded as rational attempts to account for abnormal perceptual experiences. Whilst agreeing that many delusions might well hold at least a grain of truth, and pointing out that generated beliefs must somehow be maintained by the perception of evidence in its favour, Bentall (1992) summarises the evidence which clearly indicates that reasoning biases are present in deluded patients. For example, some, but not all, deluded subjects were overconfident and made less effort to seek information when making probabilistic decisions than were normal controls (Huq, Garety and Hemsley, 1988). Bentall, Kaney and Dewey (1991) further found that deluded patients were excessively biased in making person (i.e. internal) attributions for negative actions. Deluded patients also have an attentional bias towards threat-related words (Bentall and Kaney, 1989). Finally, deluded patients recalled fewer propositions overall but recalled more propositions with threat-related content when asked to recall stories with and without threat-related words (Kaney, Wolfenden, Dewey and Bentall, 1992). This latter study is of particular note as it emphasises the presence of both memory deficit and cognitive bias. It is suggested that any attempt to provide a comprehensive cognitive neuropsychological account of delusion formation and retention may have to integrate both cognitive deficit and cognitive bias.

It would also be interesting to determine how mood state might influence the formation of delusions. Delusional symptomatology is frequently associated with extreme distress, although the direction of causality is far from clear. In line with the stress-vulnerability hypothesis (Zubin and Spring, 1977), it should also be noted that the first and subsequent onsets of illness are frequently preceded by an increased occurrence of stressful life events. That is, onset of illness typically occurs when the subject is in a state of high arousal, a state which may well influence the development of symptomatology. There is considerable

evidence that anxiety is associated with a cognitive bias favouring the processing of threat-related information, which appears to reflect a bias in the assignment of processing priorities (e.g. MacLeod and Mathews, 1991). The reasoning biases demonstrated to be present in deluded subjects may well operate in a parallel fashion to the mechanisms known to be involved in the formation and maintenance of anxiety-related thoughts.

To summarise, memory impairments have been reliably demonstrated in schizophrenia. Overall, the picture seems to be one of preserved intelligence and short-term memory with marked deficits in long-term episodic memory and in semantic memory. As yet, no model has adequately related such impairments to the observed clinical phenomena of schizophrenia. It has been suggested, though, that one explanation of the route to the formation of delusions lies in the concept of a disorder of real-world knowledge. It is suggested that a comprehensive theoretical model of delusion formation and maintenance might have to take into account not only impairments in memory, but also reasoning bias and possibly the influence of mood state.

1.2.4 Impairments in executive functioning in schizophrenia

The frontal lobes constitute approximately one-third of the brain. Thus, as David (1992) eloquently points out, "localising a disturbance in this region is rather like a person directing a visitor to an address marked Europe" (p.244). Despite this, there is a common agreement that the frontal lobes carry out executive functions. These functions are held to be cognitive processes that allow the subject to respond and adapt appropriately to his/her environment, and involve the planning, execution and monitoring of action; the integration of behaviours into purposeful activity; and the maintenance of level of arousal (Levin,

Yugelun-Todd and Craft, 1989). As noted previously, it was Kraepelin who first identified a disorder of attention as being related to schizophrenic behaviour. His classic description of "dementia praecox" is reminiscent of Luria's (1980) description of the frontal lobe syndrome, particularly with respect to the negative symptoms of schizophrenia.

1.2.4.1 Executive dysfunction and brain localisation in schizophrenia

Some blood flow, positron emission tomographic (PET) and electroencephalographic (EEG) studies of schizophrenic patients have shown a modest consistency in results indicating reduced frontal lobe function, but others have found hyperfrontality. Such studies have been beset by methodological differences and because of these it is difficult to draw any firm conclusions from such work. Despite these difficulties, several models of brain dysfunction in schizophrenia presuppose an association between attention and the frontal lobes. For example, Seidman (1983) proposed that brain dysfunction in schizophrenia was related to changes in the activation of a cortico-subcortical, arousal-attention system that includes brain-stem, limbic and fronto-temporal areas. Similarly, Levin (1984a) hypothesised a "dysfunction of frontal lobe mechanisms that mediate attention and motor behaviour, specifically those involving the mesocortical dopamine projections to the dorsolateral frontal cortex, as well as the subcortical inputs to the same region" (p.68). She argued that the poor performance of schizophrenic subjects on many tasks was due to factors such as distractibility, inability to focus attention, slowness in nonreflexive responses and perseveration, and noted that such impairments were frequently associated with poor arousal and decreased motivation. Both Seidman and Levin suggested that negative symptoms in particular may be associated with frontal-type impairments, noting the parallels between symptoms such as social withdrawal, blunted

affect, distractibility, apathy and loss in initiative, and the behaviours exhibited by patients with frontal lesions.

1.2.4.2 Impaired performance on tests of executive functioning in schizophrenia

Several studies provide support for the notion of executive dysfunction in schizophrenia. Kolb and Wishaw (1983) assessed patients with schizophrenia and normal control subjects on a comprehensive neuropsychological battery of tests. They found that the schizophrenic subjects as a group performed worse than the control group on all the cognitive measures administered. In addition, they reported differential impairment on tests allegedly sensitive to frontal lobe function in the schizophrenic group relative to other functions. Similar results are reported by Taylor and Abrams (1984). Weinberger, Berman and Zec (1986) reported that schizophrenic subjects differed from normals in relative change of prefrontal activity during the Wisconsin Card Sorting Test and number-matching tests; this did not appear to be secondary to an attentional deficit although the results may have been a non-specific effect of patients' inability to perform a difficult task. In order to test the hypothesis that impaired performance on the WCST is not solely the consequence of poor motivation and attention, Goldberg, Weinberger, Berman, Pilskin and Podd (1987) manipulated the test conditions. Performance increased when direct instruction was given whilst subjects were engaged on the test, but learning was not maintained despite this intervention. The results were interpreted as being consistent with prefrontal processing deficits, not attributable to poor motivation or attention. Shallice, Burgess and Frith (1991), using a single case study approach to neuropsychological investigation, also found evidence of an executive dysfunction in schizophrenia. Within their small group of schizophrenic patients (n=5) they found a general cognitive deficit

affecting all subjects to varying degrees, with each subject's neuropsychological profile indicating a different pattern of cognitive impairment. Importantly, they also observed an impairment in executive function which uniquely was found in all of the sample.

Other studies have reported evidence that seems contrary to the hypothesis of selective impairment in tests allegedly sensitive to frontal lobe dysfunction. For example, Saykin et al (1991, 1994) found a selective impairment of learning and memory against a background of generalised impairment in their 36 unmedicated schizophrenic patients relative to normal controls. Although the patients performed more poorly than controls on the WCST, "abstraction" was one of the least impaired functions overall, which they argue suggests that there is no selective impairment on tests related to frontal system function. A closer look at the results, however, reveals that the authors grouped Trail Making Tests A and B, Digit Symbol and Stroop tests under the function heading "visual-motor processing and attention". Trails B and the Stroop tests are generally held to be good tests of executive function, and in this study the averaged results of these tests were the fourth most impaired relative to controls, although it should be pointed out that they were not three standard deviations below the mean as were the results of the memory assessments.

1.2.4.3 Impairments in executive functioning and schizophrenic symptoms

There is strong support for the hypothesis that schizophrenia is associated with impairments of executive function. Evidence comes from a variety of sources, including controlled studies and a single-case study approach. How executive impairments relate to clinical descriptions within a schizophrenic population remains to be clarified. It should be noted that deficits in executive function are not specific to schizophrenia. For example,

Tien, Ross, Pearlson and Strauss (1996) examined the specificity of eye movement disorders to schizophrenia. During the smooth pursuit task, the schizophrenic group made a higher proportion of errors than did bipolar disorder patients or normal controls. However, the bipolar patients performed worse in the antisaccade task, which was in turn related to performance on the Wisconsin Card Sorting Test, a test allegedly sensitive to frontal lobe function.

Frith (1992) assigns a central role to executive function in the neuropsychology of schizophrenia, as described in detail in section 1.2.2. Although Gray et al (1991) focus more on the role of memory (see section 1.2.1), even their model arguably relies heavily on the concept of executive functioning. Both the 'central monitoring system' and the 'comparator' carry out processes generally regarded to be executive in nature, overseeing the route from planning an action to its execution. Exactly how the disruption of executive function relates to symptomatology, however, is not yet clear. Both Frith (1992) and McKenna (1991) have proposed ways in which faulty central monitoring of willed intentions may contribute to the genesis of specific symptoms such as delusions. More specifically, Frith (1992) proposed a specific link between an impairment in the ability to inhibit inappropriate responses and incoherence of speech (see section 1.2.2). Indeed, preliminary support for this hypothesis was provided by Frith et al (1991b) who found that incongruity of affect and incoherence of speech were associated with impaired performance on a Continuous Performance Task. The association between executive dysfunction and schizophrenic symptomatology will be discussed in more detail in section 1.5, where attempts to define schizophrenic syndromes and their relation to neuropsychological test performance shall be considered.

1.3 Cognitive impairments in other disorders

Deficits in memory and executive functioning are not exclusive to schizophrenia. Cognitive impairments have been reliably demonstrated to be associated with a variety of other psychiatric disorders, most notably depression. It is possible, therefore, that a significant proportion of the observed variance found in the neuropsychological performance of schizophrenic subjects might be explained by elevated levels of depression and anxiety, which have been reported to co-exist with symptoms of schizophrenia in a number of studies (see section 1.1.2). The following sections review the accumulating evidence which supports the hypothesis that depression (section 1.3.1), and to a lesser extent anxiety (section 1.3.2), are associated with significant levels of cognitive impairment.

1.3.1 Memory impairment in depression

There is substantial evidence that depression is associated with impaired performance on memory tasks. For example, unipolar patients with endogenous depression have been shown to display deficits of learning in tests of immediate and delayed recall of various forms of stimulus material (Cronholm and Ottosson, 1961; Sternberg and Jarvik, 1976). Other studies have reported: no impairment in short-term memory (e.g. Austin et al, 1992; Richards and Ruff, 1989); impairment in semantic memory (Caine, Boghos and Yerevanian, 1984); impairment in explicit but not implicit memory (Watkins, Mathews, Williamson and Fuller, 1992; Denny and Hunt, 1992) although Elliott and Greene's (1992) study found impairment on both aspects; and impairment in delayed recall and recognition for both verbal and visuo-spatial memory (e.g. Austin et al, 1992; Caine et al, 1984).

Ilsley, Moffoot and O'Carroll (1995) attempted a "detailed fractionation of different aspects of memory dysfunction in major depression in an effort to characterise which aspects of mnemonic function are selectively affected in major depression" (p. 1). Their comparison of 15 patients who fulfilled the DSM - III - R criteria for major depression with 15 age- sex- and intelligence-matched controls on a battery of memory tests found no impairment relative to controls on tests of short-term memory, semantic memory, implicit memory nor on tests of recognition memory. Significant deficits in immediate and delayed free recall of stimulus material and impaired performance on tests of psychomotor speed were found in the patient group relative to controls. The authors concluded that the selective deficit in recall was suggestive of impairment in search and retrieval processes whilst the encoding of material remains relatively intact.

1.3.1.1 Memory impairments and the level of depressed mood

The results of various studies suggest that the degree of memory impairment is correlated with the level of depressed mood. Ilsley et al (1995) did not find such an effect, but their study had only 15 subjects. In a larger study (n=40), Austin et al (1992) reported that the more severe the depressive illness, the more profound the cognitive impairment on tests of memory and psychomotor speed. Furthermore, the level of impairment appears to decrease with a reduction in the level of depressed mood. For example, Moffoot, O'Carroll, Bennie, Carroll, Dick, Ebmeier and Goodwin (1994) exploited the diurnal variation of mood observed in some patients with major depression. Using a mixture of pencil and paper and computerised neuropsychological tests on a sample of 20 patients fulfilling DSM - III - R criteria for major depressive episode with melancholia, it was

found that in the morning there were marked deficits of concentration, attention, working memory, episodic memory, psychomotor speed and speed of recognition memory in depressive patients compared with age and intelligence matched controls. By the evening, virtually all the measures had improved substantially, particularly those testing concentration, attention, working memory and reaction time. Other studies have shown that successful pharmacological treatment of depression is accompanied by a reduction in cognitive deficits (e.g. Sternberg and Jarvik, 1976).

1.3.1.2 Memory impairments and brain localisation in depression

Ebert and Ebmeier's (1996) review of imaging studies with repeated measures designs in depression highlighted the fact that limbic and paralimbic structures show changes in the course of the illness. Increases in the activity of medial prefrontal structures were typically reported during the more depressed state in various studies employing psychosurgery, electroconvulsive therapy (ECT) and sleep deprivation. Using the diurnal variation paradigm, Ebmeier, Cavanagh, Moffoot, Glabus, O'Carroll and Goodwin (1997) examined the relationship between symptoms and regional brain activation in depression. The within- subject analysis indicated that an increase in depression scores was associated with increased perfusion in cingulate and other paralimbic areas. The results also suggested a probable association between the occurrence of anxiety within depression and reduced frontal neocortical perfusion.

There is therefore strong support in favour of the hypothesis that depression is associated with decreased performance on memory tests, and that furthermore the level of depressed mood is associated both with the degree of cognitive impairment and with changes in the neural substrate. Many of the deficits resemble those also found to occur in the schizophrenic population. For example, the pattern of preserved short-term memory, impaired semantic memory and impaired immediate and delayed free recall has been demonstrated in both depressed and schizophrenic subjects. Cassens, Wolfe and Zola (1990) directly compared patients with a DSM - III diagnosis of major unipolar depression with a group of chronic schizophrenic inpatients on a battery of neuropsychological assessments. The groups were matched for age, education and handedness and were similar in overall, verbal and performance IQ. Unfortunately, there was a significant sex difference with all the schizophrenic subjects (n = 15) being male and all the depressed patients (n = 7) female. Interestingly, the researchers observed that whilst actual scores were frequently the same across tests for each group, the qualitative performance and nature of the errors were quite different and distinguishable. Cassens et al (1990) cite the example that depressed patients were more likely to make perseverative errors on a verbal fluency test, but chronic schizophrenic subjects were more likely to break the rules of the set, give neologisms or be unproductive for up to 15 seconds at a time. These results are clearly only preliminary findings, but indicate the need for replication of the study with a larger sample size and more qualitative analysis of the data.

1.3.1.4 Neuropsychological subtypes of depression

In their discussion, Cassens et al (1990) propose three neuropsychological subtypes of depression. They propose firstly a minimal- or no-deficits group, who might be most responsive to psychotherapy as opposed to medication. The second group that emerged from the analysis showed relatively focal neuropsychological dysfunction in addition to attentional deficits. It was suggested that this group of patients might be most responsive to a combined medication and psychotherapy treatment package. The final group was composed of patients with what might be alternatively described as 'pseudodementia'. That is, they had widespread neuropsychological dysfunction but gave no evidence of the quantitative or qualitative features normally observed in dementia. Such patients might respond to pharmacotherapy, electroconvulsive therapy and psychotherapy. The authors argue that "it may prove more fruitful to subtype depressions and schizophrenias on the basis of the patient's neuropsychological profile" (p.212) which might have a potential function in the prediction of differential response to treatments.

1.3.2 Executive function in depression

Impairments in executive function are not specific to schizophrenia as previously suggested by Tien et al's (1996) study in section 1.2.4.3. For example, Yurgelun-Todd, Craft, O'Brian, Kaplan and Levin (1988) found deficits in bipolar subjects similar to those observed in patients with schizophrenia using the Wisconsin Card Sorting Test. Interestingly, their analysis of results suggested that the schizophrenic group tended to make both perseverative and 'failure to inhibit' types of errors, whilst manic-depressive patients primarily made errors involving failures in inhibition only. Executive dysfunction

in depression has also been demonstrated using neuropsychological tests such as the trail-making test (Austin et al, 1992), the Stroop colour word test (Trichard, Martinot, Alagille, Masure, Hardy, Ginestet and Feline, 1995) and letter fluency (Robertson and Taylor, 1985; Trichard et al, 1995), although the results have not always been consistent.

There is also growing evidence linking depression with dysfunction in the frontal lobes and with impairment of executive function. In brain injured patients, depression may result from damage to either frontal lobe, although left frontal infarcts are more likely to induce a depressive state (Robinson, Starr, Kubos and Price, 1983a). Conversely, PET scans and studies of regional cerebral blood flow (rCBF) have found evidence of decreased rCBF in the left anterior cingulate and the left dorsolateral prefrontal cortex (DLPFC) of depressed patients (Bench, Friston, Brown and Scott, 1992; Baxter, Schwartz, Phelps, Mazziotta, Guze, Selin, Gerner and Sumida, 1989). Recovery from depression appears to reverse the trend in the DLPFC whilst the abnormalities in the cingulate appear to stay relatively stable (Bench, Friston, Brown, Frackowiak and Dolan, 1993).

Cognitive models of depression have suggested that the deficits known to occur in depression might be understood in terms of impaired processing on effortful tasks with intact automatic processing (e.g. Hartlage, Alloy, Vazquez and Dykman, 1993). Effortful tasks are said to draw upon resources available to the central executive component of working memory (Baddeley and Hitch, 1974). This limited resource information-processing system has been previously linked with the frontal lobes. A central question, therefore, is how much of the variance in the cognitive deficits observed in depressed patients is explained by a specific functional impairment and how much is accounted for by a general motivational deficit. To date, Richards and Ruff's (1989) study has strongly

suggested that the impaired performance of depressed patients on cognitive tests was not simply attributable to a reduction in motivation. Further clarification of this issue must await the production of neuropsychological tests well matched for task difficulty.

1.3.2.1 Executive functioning and the level of depressed mood

Similar results have been found in only mildly depressed or dysphoric subjects. For example, Channon (1996) found greater impairments on the WCST in their group of dysphoric undergraduates compared to a healthy control group, whilst Baker and Channon (1995) claimed that dysphoric subjects showed similar patterns of impairment to clinically depressed subjects on discrimination learning problems (Silberman, Weingartner and Post, 1983). Supporting the hypothesis that impairments on tests of executive function correlate with level of depressed mood, Trichard et al (1995) found that the performance of patients with severe depression on the verbal fluency test improved in relation to clinical amelioration of symptoms. It remains to be determined whether these results can be explained solely in terms of a non-specific effect of psychomotor-retardation. Whilst heeding this caution, there is some evidence to support the hypothesis that executive dysfunction accompanies depression, at all levels of severity. In addition, in at least one study (Trichard et al, 1995), a test of verbal fluency appeared to act as a state marker for depression.

1.3.3 Cognitive Functioning in Anxiety

There is less evidence linking anxiety with decreased performance on neuropsychological tests. The main hypothesis is that anxious patients may experience a diminution of

attention to external stimuli, but the vast majority of work has concentrated on cognitive biases, characterised by processing advantages for threat related stimuli, which have been reliably demonstrated on a number of cognitive tasks. MacLeod and Mathews (1991a) found evidence that such cognitive biases reflect a bias in the assignment of processing priorities rather than the enhanced availability of threat-related information from memory. This begs the question raised at the beginning of section 1.2.3.5. That is, what is the nature of the relationship between cognitive biases and cognitive impairments?

There is far less research into the cognitive impairments that may accompany anxiety states, although there is some consensus that, overall, anxiety is associated with decreased performance across a wide range of tasks. The strongest predictors of performance deficit appear to be measures of immediate mood state rather than measures of trait anxiety (Spielberger, Gorsuch and Lushene, 1970). On easier tasks, anxiety may facilitate performance. At the beginning of this century, the Yerkes-Dodson law was established (cited in Corsini, 1984). That is, there is an optimal level of arousal for the performance of tasks. If arousal is below or above this critical level, learning and performance are impeded.

Studies of the efficiency of attention in non-clinical samples have shown an association between decreased task performance and level of anxiety. For example, using college undergraduates, Buckelew and Hanney (1986) found that subjects who scored highly on a measure of state anxiety performed worse on the Block Design subtest of the Weschler Adult Intelligence Scale (WAIS) and a simple word fluency test than did subjects who had a low score on the same anxiety measure. This is not a consistent finding, however. Using a similar sample, Chavez, Trautt, Brandon and Steyaert (1983) found that test anxiety had

no effect on the performance of the Digit Symbol or Digit Span subtests of the WAIS nor on the Trail Making Tests. There are still fewer studies of anxious patients and neuropsychological performance. Yeudall, Schopflocher, Sussman, Barabash, Warneke, Gill, Otto, Howarth and Termansen (1983) found that patients with a diagnosis of panic disorder achieved significantly lower scores on a variety of neuropsychological tests, including Trail Making Part B, Oral Word Fluency and WAIS Verbal IQ when compared to a normative data base, but there appear to be no reports of well controlled studies.

As yet, there do not appear to have been any reports of studies looking specifically at memory impairments in anxious patients, despite the hypothesis that anxious patients may focus less on external stimuli because attentional resources are diverted towards particular worries, suggesting a potential difficulty in encoding abilities. In general, there is obviously scope for further research into the associations between impaired cognitive abilities and anxiety.

1.3.4 Emotional correlates of neuropsychological test performance

Several studies have looked at emotional correlates of neuropsychological test performance, but these have found, at best, only a moderate association between emotional variables and impairment on tests of cognitive function in psychiatric patients. For example, Gass and Daniel (1990) concluded that the test performance of their mixed diagnosis patients on the Trails B test was "resilient to a variety of emotional influences" as rated by the Minnesota Multiphasic Personality Inventory (MMPI). The effect of emotional factors on performance of the Halstead-Reitan Battery (Caslyn, Louks and Johnson, 1982), the Oral Word Association Test, Design Fluency and WISC-R (Gass,

Ansley and Boyette, 1994) has been studied. In each case the effect was small. Both of these studies also used the MMPI as a measure of emotional disturbance. It is suggested that, given the finding that performance is best predicted by immediate mood state rather than by trait performance, the MMPI may not be the most appropriate instrument for measuring emotional correlates of test performance.

1.3.5 Summary

Recent research has highlighted the cognitive impairments that accompany not only schizophrenia, but also depression, and to a lesser extent, anxiety. The evidence suggests that these disorders are associated to a greater or lesser extent with deficits in both learning and memory and executive functioning. As outlined in section 1.1.2, there is now also considerable evidence that symptoms of anxiety and, in particular, depression co-exist with the expression of schizophrenia. Accordingly, the main hypothesis of the present study is that anxiety and depression will explain a significant proportion of the variance observed in the neuropsychological test performance of patients suffering from schizophrenia. The present study will utilise a between-subjects design. It should be noted, therefore, that the literature reviewed suggests that state depression looks far more promising as a predictor of neuropsychological test performance than does state anxiety.

1.4 Generalised versus specific cognitive deficits in schizophrenia

As is already evident from the various studies discussed in sections 1.2.3 and 1.2.4, different studies have found different patterns of deficits in the neuropsychological test performance of patients with schizophrenia. These discrepancies parallel the lack of

consensus pertaining to the brain localisation of the 'site' of schizophrenia described in section 1.2. To summarise, there is considerable debate as to whether there is a generalised neuropathology (e.g. Meehl, 1990), whether there is hemispheric localisation (e.g. Crow, 1990; Cutting, 1985) or whether discrete neuroanatomical regions may be implicated in schizophrenia (e.g. Weinberger, 1987; Buschbaum, 1990).

1.4.1 Generalised cognitive impairment in schizophrenia

In neuropsychological terms, some authors have argued that schizophrenia is accompanied by a generalised deterioration across all aspects of cognitive functioning. For example, Blanchard and Neale (1994) carried out a comprehensive neuropsychological assessment of 28 medication-free schizophrenic patients and 15 matched normal control subjects. They found that, relative to controls, the schizophrenic subjects were impaired on a range of cognitive tests, including measures of motor, sensory and perceptual functioning, various memory indices, and tests allegedly sensitive to frontal lobe functioning. The authors concluded that schizophrenia was associated with "significant generalised, bilateral neuropsychological impairment". However, Blanchard and Neale (1994) did caution that their own findings, as well as those of other studies, were confounded by the fact that the majority of neuropsychological tests are not psychometrically matched. As such, the tests have differential discriminating power which makes it extremely difficult to draw firm conclusions about the presence or absence of any disproportionate deficit in schizophrenia.

1.4.2 Disproportionate cognitive deficits in schizophrenia

Whilst taking on board Blanchard and Neale's (1994) cautionary note, other researchers have presented evidence consistent with a disproportionate deficit hypothesis. Saykin et al's (1991; 1994) studies have already been discussed in section 1.2.3.1. With samples of medication-free schizophrenic patients, the results of both studies suggested that, in comparison with healthy controls, there was a generalised cognitive impairment on all neuropsychological tests. In addition, however, the schizophrenic sample showed a differentially worse performance on tests of learning and memory relative to their performance on tests sensitive to other aspects of cognitive functioning.

On the other hand, at least two studies suggest disproportionate deficits in executive function compared to other cognitive functions. Taylor and Abrams (1984) found that their schizophrenic subjects differed significantly from normal controls on all neuropsychological measures, and that furthermore they "showed bilateral impairment that was comparatively worse in the dominant frontotemporal regions" (p.196). In addition, Kolb and Wishaw (1983) (see section 1.2.4.2) found that schizophrenic patients were significantly impaired on all tests allegedly affected by left or right frontal lobe lesions. Finally, Shallice et al (1991) (see section 1.2.4.2) found that the schizophrenic subjects in their small sample (n=5) all showed evidence of a disproportionate impairment in executive function relative to other functions. This was despite otherwise heterogeneous neuropsychological profiles on these other functions.

1.4.3 Summary

To recapitulate, few studies to date have directly addressed the question of whether there is a generalised or disproportionate cognitive deficit associated with schizophrenic neuropsychological test performance. So far, the results that have been published have demonstrated a considerable degree of inconsistency. If there is a disproportionate deficit, the evidence would suggest that the impairment lies either in learning and memory, or in executive function, or both. The second aim of the present study is therefore to add to this debate by comparing the performance of patients with schizophrenia on neuropsychological tests of memory and executive function, relative to the test performance of normal controls.

1.5 Syndromes in schizophrenia

Gray et al's (1991) model, described in detail in section 1.2.1, attempted to account for the phenomena experienced in acute schizophrenia. Frith's (1992) theoretical account (see section 1.2.2) proposed an underlying cognitive abnormality in the concept of self-awareness, thereby attempting to account for the positive and negative symptoms which occur in both acute and chronic schizophrenia. The clinical heterogeneity of schizophrenic illness has led to many attempts to identify distinct subtypes of the disorder. For example, Crow (1980a) proposed two types of schizophrenia based on the positive-negative symptom dichotomy. The two types were not viewed as mutually exclusive, but as independent dimensions of the illness reflecting different underlying pathological processes. Thus, Crow's Type I schizophrenia was characterised by positive symptoms

which generally occurred in the setting of an acute illness whilst Type II was characterised by negative symptoms, reflecting a more chronic course of illness.

1.5.1 Three main syndromes in schizophrenia: (Liddle, 1987)

Liddle (1987b) argued convincingly that the positive-negative symptom dichotomy may well reflect the "tendency for symptoms to segregate into groups on the basis of their tendency to persist" (p.145). He examined the segregation of schizophrenic symptoms in a group of chronic schizophrenic subjects who were relatively homogenous with regard to chronicity (Liddle, 1987a). The initial factors were extracted by the method of principal factors and were then subjected to oblique rotation. The symptoms of the patients in this study segregated into three syndromes. Liddle (1987a) described these as: the psychomotor poverty syndrome, characterised by poverty of speech, blunted affect and decreased spontaneous movement; the disorganisation syndrome, marked by inappropriate affect and various forms of thought disorder; and the reality distortion syndrome which consisted of delusions and hallucinations. The three syndromes were not strongly correlated. There was a weak negative correlation ($r = -0.22$) between the factors described as the psychomotor syndrome and the disorganisation syndrome whilst the other correlations were near zero. Liddle (1987a) argued that, since patients had symptoms from more than one syndrome, the results reflected discrete pathological processes occurring within a single disease. He suggested that "there is a fundamental abnormality in schizophrenia, which in any individual case might be associated with one or more of three distinct pathological processes, depending on the patient's constitution and current environment" (p. 150), a suggestion consistent with the stress-vulnerability hypothesis (Zubin and Spring, 1977). The three syndromes described by Liddle (1987a) have been

replicated on several occasions since, by Liddle and Barnes (1990), and with much larger samples using a variety of assessment tools (e.g. Johnstone and Frith, 1996; Vazquez-Banquero, Lastra, Numez, Castenedo and Dunn, 1996; Serretti, Macciardi and Smeraldi, 1996). Liddle's three main schizophrenic syndromes would therefore appear to be a robust finding.

1.5.2 Schizophrenic syndromes and neuropsychological performance

In a second paper, Liddle (1987b) reported the correlations of the three syndrome scores with both neuropsychological performance and neurological dysfunction. In the sample of 47 schizophrenic patients whose duration of illness ranged from 3 - 18 years, it was found that the psychomotor poverty syndrome was associated with poor performance on tests of long-term memory, object naming and conceptual thinking. The disorganisation syndrome correlated with poor performance on the tests of concentration, immediate recall and word learning. Both the psychomotor poverty syndrome and the disorganisation syndrome were also associated with cortical neurological signs as measured by a modified version of Quitkin, Rifkin and Klein's (1976) neurological examination for schizophrenia and character disorders. Liddle (1987b) concluded that the results were consistent with the hypothesis that the two syndromes were associated with dysfunction at two different sites within the frontal lobes. The third syndrome, reality distortion, was associated only with poor performance on a test of figure-ground perception.

Liddle and Morris (1991) further examined the hypothesis that both psychomotor poverty and disorganisation are associated with impaired performance in neuropsychological tests allegedly sensitive to frontal lobe dysfunction, with each of the two syndromes being

associated with a different pattern of 'frontal' neuropsychological impairments. They found, not surprisingly, that psychomotor poverty was associated with slowness of mental activity (as evidenced by impaired verbal fluency) and that disorganisation was associated with impairment on tasks in which the subject is required to inhibit an established but inappropriate response (e.g. a version of the Stroop test, Trails B and the Modified Card Sorting Test). That is, the disorganisation factor seems to reflect a disturbance in mental processing involving the mechanisms of attention, particularly the suppression of irrelevant or inappropriate material. These results were therefore consistent with Liddle's (1987b) hypothesis concerning the association of the syndromes of psychomotor poverty and disorganisation with neuropsychological tests allegedly sensitive to frontal lobe function.

Furthermore, Frith et al (1991b) found that incongruity of affect and incoherence of speech, two symptoms of schizophrenia which resemble what Liddle (1987) described as the disorganisation syndrome, were associated with failure to inhibit inappropriate responses on a Continuous Performance Task. Poor performance on this sort of test suggests impaired executive functioning of a similar kind to that found by Liddle and Morris (1991). Frith et al's (1991b) result is also consistent, of course, with Frith's (1992) hypothesis that the 'behavioural abnormalities' of schizophrenia (negative symptoms as well as incongruity of affect and incoherence of speech) might result from a failure to inhibit inappropriate responding (see section 1.2.2).

Not all studies have found support for Liddle's (1987) and Frith's (1992) hypotheses concerning the nature of the relationships between schizophrenic syndromes (or symptoms) and neuropsychological test performance. Norman, Malla, Williamson,

Morrison-Stewart, Helmes and Cortese (1997a) tested the predictions made by Liddle's three-syndrome model of schizophrenia with a sample of 87 schizophrenic patients. They found no support for the hypothesis that symptoms of psychomotor poverty would be correlated with impaired performance on neuropsychological tests allegedly sensitive to dorsolateral prefrontal cortex functioning, nor for the prediction that the disorganisation syndrome would be associated with impaired performance on tests supposedly sensitive to medio-basal prefrontal functioning. On the other hand, as predicted by Liddle's model, Norman et al (1997a) did find evidence of a particular correlation of the reality distortion syndrome with a measure of verbal memory, often considered to be related to left temporal lobe functioning.

1.5.3 Syndromes in acute and chronic schizophrenia

As previously stated in section 1.1.2, Rogers (1996) further explored this notion of a segregation of symptoms and the subsequent syndromes' relationships with neuropsychological functioning. Ratings from the Positive and Negative Symptoms Scale (Kay et al, 1986) for patients at the acute stage of schizophrenia and for chronic patients were entered separately into a factor analysis, which employed the method of principal components followed by an oblique rotation. For chronic subjects, four factors reflecting what Rogers (1996) called reality distortion (explaining 23.4% of the variance), poverty of sociability and affect (18.4%), disorganisation (14.9%) and excitability (8.4%) emerged. Unfortunately, the correlations between the syndromes were not reported. Poverty of sociability and affect was associated with impaired short term working memory, episodic memory and semantic verbal fluency. Disorganisation was associated with impaired episodic memory and disinhibition of inappropriate responding. Both these results

therefore provide only partial replication of earlier findings (e.g. Liddle and Morris, 1991). Neither of the other two syndrome scores were associated with neuropsychological test performance.

The analysis of the acutely ill schizophrenic patients' symptoms produced five different factors, which Rogers (1996) called 'paranoid state', 'poverty of affect', 'grandiosity', 'disorganisation and poverty of sociability', and 'reality distortion'. In this acute group, none of the factors were significantly related to neuropsychological functioning. Given the demands of the statistical analysis employed, this might reflect the small number of subjects (n=26). Overall, it was found that both the chronic and the acute subjects were impaired on executive, memory and psychomotor functioning compared to normal controls. The authors concluded that the lack of any significant relationships between the acute factors and neuropsychological functioning might reflect the "instability of symptom expression, at this stage, invalidating the sub-syndromes as reliable indicators of sub-pathologies" (p.viii).

The first three factors which emerged from Rogers' (1996) analysis of the group of chronic patients resembled the factors that emerged from Liddle and colleagues' series of studies which employed the Manchester scale (Krawiecka, Goldberg and Vaughan, 1977). It should be noted that Rogers argued that lack of spontaneity and flow of speech, poor rapport, emotional withdrawal and passive/apathetic social withdrawal encapsulated the idea of 'poverty of sociability and affect' rather than 'psychomotor poverty' as Liddle described this syndrome. It is also of note that a fourth syndrome, 'excitability', characterised by grandiosity and hostility and therefore arguably reflecting an affective component, emerged from the later study. This perhaps reflects the greater

comprehensiveness of the PANSS, and provides a timely reminder that the results of factor analytical studies can be substantially influenced by the measures which are selected for data analysis. Given that a number of other studies have failed to observe a fourth syndrome and have rather replicated Liddle's (1987) three main syndromes (see section 1.5.1), there is a need to replicate Roger et al's (1996) study before any firm conclusions may be drawn.

1.5.4 Schizophrenic syndromes and brain function

Finally, a few studies have attempted to explore the relationship between the three main schizophrenic syndromes and brain localisation of function. For example, Liddle, Friston, Frith, Hirsch, Jones and Frackowiak (1992) used PET scans to study the relationship between regional cerebral blood flow (rCBF) and symptom profiles. They found that psychomotor poverty and disorganisation were associated with activity in the pre-frontal cortex, whilst reality distortion was associated with altered perfusion in the medial temporal lobe. This latter association was interpreted as being consistent with Frith and Done's (1988) hypothesis that the deficit underlying reality distortion is a failure of internal monitoring, with the neurological basis for such a deficit being an impairment of the link between the medial temporal lobe and frontal cortex.

Using magnetic resonance imaging (MRI) scans from the same patients used in Liddle et al's (1992) PET scan study, Chua, Wright, Poline, Liddle, Murray, Frackowiak, Friston and McGuire (1997) found a significant negative correlation between the psychomotor poverty syndrome score and the relative volume of the left ventro-medial prefrontal grey matter. This association resembled the pattern observed with rCBF in the same patients,

leading the authors to conclude that the observed functional abnormality was related to an underlying anatomical change. Conversely, Chua et al (1997) found a positive correlation between the disorganisation syndrome score and the relative volumes of the medial temporal cortex, with foci in the hippocampus and the parahippocampal/fusiform gyrus of both hemispheres, a result at odds with the previous rCBF findings. No correlation was found between the reality distortion syndrome score and relative grey matter volume.

Finally, Norman, Malla, Williamson, Morrison-Stewart, Helmes and Cortese (1997b) explored the possible relationships that might exist between disruptions in the connection between frontal and temporal areas, and frontal and occipital areas of the brain, and the three main schizophrenic syndromes. They assessed 73 patients with schizophrenia using a measure of electroencephalographic (EEG) coherence under conditions of activation by a mathematical task and a visuo-spatial task. The coherence measures were then correlated with the syndrome scores. It was found that only left frontal-temporal connectivity had a significant negative relationship to symptomatology, specifically to the reality distortion syndrome. However, this was true only for male subjects.

1.5.5 Summary

With the exception of the findings of Rogers (1996), there is substantial support for Liddle's (1987) three-syndrome model of schizophrenia. There is preliminary support for the notion that the psychomotor poverty syndrome and the disorganisation syndrome are associated with different patterns of neuropsychological performance on tests of executive functioning, but the research to date shows some inconsistency. Recent studies have exploited modern brain imaging techniques to investigate the relationships between

schizophrenic syndromes and brain activity or structure. The results of such studies have been somewhat inconclusive, but with the technological advances in the techniques used and larger sample sizes, this is likely to be a promising area of research.

The current study aims to provide further support for Liddle's (1987) three-syndrome model of schizophrenia. Using the extracted syndrome scores, the research will then test the hypothesis that the psychomotor poverty syndrome and the disorganisation syndrome are associated with different patterns of performance on tests of executive function, a premise which has already received preliminary support. Furthermore, the study will test the hypothesis that the reality distortion syndrome will be correlated with tests of memory, for which there is far less evidence to date.

1.6 Methodological considerations

Various factors are known to influence neuropsychological test performance. Thus, any piece of research employing cognitive tests must account for such variables. Before going on to re-iterate the hypotheses of the present study, various confounding variables such as the effects of medication and demographic factors shall be briefly discussed.

1.6.1 Medication and neuropsychological performance

The effects of medication on memory in patients with schizophrenia have been briefly discussed elsewhere (section 1.2.3.1). Several reviews have concluded that, overall, neuroleptic medication appears to have a relatively minor impact on most neuropsychological tasks (e.g. Heaton and Crowley, 1981; Spohn and Strauss, 1989). This

might also be true of the newer, atypical neuroleptic drugs. For example, Goldberg et al (1993) found that although clozapine treatment resulted in marked improvements in psychiatric symptoms, but had no effect on measures of cognitive function. Indeed, some studies have even suggested that neuroleptic medication improves the neuropsychological performance of patients with schizophrenia (e.g. King, 1990). Kirkpatrick, Golden and Fletcher (1987) argued that years of exposure to neuroleptic medication might exert a cumulative negative effect on cognitive function. If this were the case, one would expect the effects to be greatest in chronic, severely ill patients. However, Buhrich, Crow, Johnstone and Owens (1988) found no relationship between presence of general intellectual impairment and lifetime neuroleptic exposure as categorised by 'none', 'some' or 'much'.

Anticholinergic medication, given to treat neuroleptic-induced extrapyramidal symptoms, must also be considered as a potentially serious confounding factor. Frith (1984) has demonstrated that anticholinergic medication can impair memory under experimental conditions. Furthermore, Tune, Strauss, Lew, Breitlinger and Coyle (1982) found a correlation between impaired cognitive performance and blood anticholinergic levels, although this was only partially replicated by Perlick, Stastny, Katz, Mayer and Mattis (1986). On the other hand, a number of studies have found no or equivocal differences on neuropsychological measures between anticholinergic treated and untreated groups of schizophrenic patients (e.g. Calev, 1984a,b; Goldberg, Weinberger, Pilskin, Berman and Podd, 1989).

Perhaps the most convincing argument against the hypothesis that neuroleptic and anticholinergic medication explain the apparent cognitive impairments in schizophrenia is

the reminder that such deficits had been observed in patients before the widespread use of neuroleptic and adjunctive medication. It is suggested, therefore, that although the medication used in the management of psychotic illness may have the potential to cause mild cognitive deficits, the medication cannot wholly account for the impairments found. In the present study, an attempt was made to control for the potential effects of medication by recording the dosage of antipsychotic and anticholinergic medication for each subject and correlating these with neuropsychological test performance.

1.6.2 Appropriate control groups

There has been some debate about the most appropriate control group to use in studies of schizophrenia. Neuropsychological performance may be significantly related to both age and education (e.g. Heaton, Grant and Mathews, 1986; Warner, Ernst, Townes, Peel and Preston, 1987) as well as to gender and handedness (e.g. Heaton et al, 1986; Filskov and Catanese, 1986). Most studies have attempted to use control groups matched on such factors as IQ, years of education and socio-economic status. In schizophrenic research though, even this may not be the foolproof method it may first appear and has been referred to by Meehl (1970) as the 'matching fallacy'. That is, the onset of the disease of schizophrenia impedes education and produces the phenomenon known as 'downward drift' (Dohrenwend and Dohrenwend, 1969). Matching patients and controls might therefore result in the comparison of 'overachieving patients with underachieving controls' (Saykin et al, 1991; p.619). The debate remains open, but any study should at least attempt to control for such confounding variables. The present study controlled for age, socio-economic status and years in education in the statistical analyses, and the experimental and control groups were matched for sex.

1.6.3 Chronicity and severity of illness

Overall, the consensus appears to be that there is no association between duration of illness and level of cognitive functioning (e.g. Goldberg, Ragland, Torrey, Gold, Bigelow and Weinberger, 1990). Perhaps the most striking illustration of this point is the fact that patients with first episode schizophrenia have been demonstrated to display a significant level of cognitive impairment (e.g. Saykin et al, 1994). Similarly, there is evidence against the hypothesis that symptomatology interferes with cognitive functioning in patients with schizophrenia. For example, Goldberg et al (1993) concluded from the results of their study that cognitive dysfunction is, to a considerable degree, independent of presence or severity of psychopathology. In order to control for any potentially confounding effect of chronicity or severity of illness on the test results, these variables were recorded for each patient and subsequently correlated with neuropsychological test performance.

1.6.4 Motivation and task difficulty

It has been questioned whether many patients with schizophrenia are either able or willing to take part in neuropsychological assessment. Furthermore, it must be queried whether the deficits observed in patients with schizophrenia on cognitive tests can be attributable to motivational effects. Again, however, the consensus is that results from such tests are not wholly attributable to differences in co-operation or motivation (e.g. Goldberg et al, 1987; Lawson, Waldman and Weinberger, 1988). In an attempt to control for this problem, the present research employed a simple five-point measure of motivation and willingness to co-operate following several other authors (e.g. Shakow, 1981). It must be conceded, however, that such measures tend to be somewhat crude.

The problem of neuropsychological tests that are not well matched in terms of task difficulty has already been alluded to in previous sections (e.g. section 1.4.1). This issue is particularly problematic for the question of whether patients with schizophrenia display generalised or disproportionate cognitive deficits. Chapman and Chapman (1989) discuss this point in some detail, highlighting the fact that "unmatched tasks may either create pseudoevidence of a differential ability or mask a genuine one" (p. 359). For example, poor performance on one task relative to another might simply reflect differences in the effort required to complete a particular task. Unfortunately, there is as yet no ideal method of controlling for this complex problem. It is essential, however, to be wary of this issue when interpreting the results of any study, including the present one, that employs neuropsychological test batteries.

1.7 Aims of the present study

To summarise, the present study compared a group of heterogeneous patients with schizophrenia against a healthy control group on several neuropsychological measures of memory and executive function as well as two state measures of mood. An attempt was made to control for confounding variables such as age, sex, socio-economic status, years in education, chronicity and severity of illness, level of motivation and medication effects.
The aims were threefold:

1. To test the hypothesis that levels of depressed mood and anxiety at the time of testing may explain a significant proportion of the variance observed in the neuropsychological test performance of patients with schizophrenia.

2. To explore the nature of the pattern of cognitive impairment in patients with schizophrenia. That is, to add to the debate of whether there is a generalised cognitive impairment in patients with schizophrenia or whether such subjects display a disproportionate cognitive deficit in either learning and memory or executive functioning relative to other functions.

3. To provide a further replication of the three main syndromes proposed by Liddle (1987) and to test his hypotheses regarding the relationship of these syndromes to neuropsychological test performance.

2.0 METHOD

2.1 Subjects

2.1.1 Demographics

Fifty-two patients meeting DSM-IV criteria for schizophrenia (American Psychiatric Association, 1987) were asked to take part in the study. Eight patients did not attend their appointment or changed their mind about participating in the research before testing began. Four patients dropped out of the study during the initial stages of the assessment session. This left forty patients whose data were entered into the statistical analyses. The patients were recruited from acute, rehabilitation, out-patient and long-stay services, comprising a sample with a wide range of severity and chronicity. This sample included seven out-patients, ten patients from day hospitals, two in-patients on acute wards, five rehabilitation in-patients and sixteen patients from long-stay wards.

There were thirty-one males and nine females. Mean (S.D.) age was 42.0 years (13.3), range 22 - 70 years. Mean (S.D.) years full-time education was 12.6 years (1.9), range 10 - 19 years. A crude measure of chronicity was taken, after Tamlyn et al (1992), whereby chronicity was the mean length of time between first recorded development of psychotic symptoms and first hospital admission. Mean (S.D.) years chronicity was 19.25 years (11.61), range 2 - 51 years. Subjects' postcodes were recorded and converted to give a Deprivation Category (DepCat) using the tables provided by Carstairs and Morris (1990). These tables rate deprivation categories on a scale of 1 - 7, with 1 being the most affluent and 7 the most deprived. Mean (S.D.) DepCat was 4.20 (1.94). Each patient's social class was also recorded, using the occupational classification first developed by the Registrar

General in 1911. Social class is ranked on a scale of 1 (professional) to 5 (unskilled). The classification was made using the patients' highest premorbid occupational status. Mean (S.D) social class was 3.55 (1.08).

2.1.2 Exclusion criteria

Any patient with a history of organic brain disease or head injury was excluded from the study. As substance abuse is a known risk factor for impaired performance on neuropsychological testing (Carlin, 1986), and may be associated with impairments of executive functioning, subjects were also excluded if they had a history of alcohol or drug abuse. No patient been treated with ECT during the preceding 12 months.

2.1.3 Medication

All patients were taking neuroleptic medication at the time of testing. Levels of neuroleptic medication were converted to chlorpromazine equivalents using the conversion formulae provided by Black, Richelson and Richardson (1985) and Foster (1989). Twenty-two patients were prescribed the more recently developed atypical antipsychotic medication such as clozapine and olanzapine. Unfortunately chloropromazine equivalents were not available for these patients and consequently their data were excluded from the chloropromazine equivalent analysis. For the remaining eighteen patients, mean daily dosage in chlorpromazine equivalents = 475.7 mg, range = 50.0 - 1517 mg. Patients who were taking anticholinergic medication were included in the study. Seventeen patients were taking procyclidine, mean daily dose = 9.4 mg, range = 5 - 20 mg. Seven patients were prescribed orphenadrine, mean daily dose = 100 mg, range = 50 - 200 mg.

2.1.4 Control group

Twenty normal healthy controls were also recruited for the study. There were 9 females and 11 males. Mean (S.D.) age of the control group was 32.0 years (10.3), range 24 - 59 years. Mean (S.D.) number of years in full-time education was 14.7 years (2.5), range 10 - 18 years. Mean (S.D.) DepCat was 2.6 (1.94), and mean (S.D.) social class was 2.55 (0.76).

2.2 Measures

2.2.1 Neuropsychological tests

All subjects were administered a battery of neuropsychological assessments measuring memory and executive functions.

1. The California Verbal Learning Test (CVLT) (Delis, Kramer, Kaplan and Opler, 1987) was used as a test of episodic memory. A more 'ecological' version of the auditory verbal learning test (Rey, 1964; Lezak, 1995), subjects are presented with a 16-item shopping list (List A) five times and asked to recall as many items as possible in any order immediately after each presentation. A second list (List B) is then read out and recalled once, followed by recall and cued recall of List A. After a 20 minute delay the subjects are tested for recall, cued recall and recognition of List A. The indices used in the present study were total number of items from List A recalled over 5 trials, delayed recall and recognition.

2. The Speed of Comprehension test (Baddeley, Emslie and Smith, 1992) was employed as a measure of semantic memory. This test, a version of the 'Silly Sentences' test

(Collins and Quillian, 1969) consists of 100 written statements such as 'prime ministers have feathers' and 'roses grow in gardens'. Subjects were required to read and classify as true or false as many of these statements as possible in a two minute period. The number of statements correctly classified in the time period was recorded, as was the number of errors made. On the Silly Sentences test, healthy controls rarely make errors whereas patients with schizophrenia have been demonstrated to make a greater number of errors on this test (e.g. Tamlyn et al, 1992; Duffy and O'Carroll, 1994).

3. The orientation subscale from the Rivermead Behavioural Memory Test (RBMT) (Wilson, Cockburn and Baddeley, 1985) was used. This requires subjects to answer questions about personal details and factual knowledge about the world (e.g. "In what year were you born?" and "What is the name of the present president of the United States of America?"). It could be argued that orientation provides not only a measure of orientation but also of semantic memory.

4. The verbal fluency test (Borokowski, Benton and Spreen, 1967) is generally maintained to be a test of executive function (e.g. Austin et al, 1992) but it has sometimes been argued to be a measure of semantic memory (e.g. Ilsley et al 1995). Subjects are required to generate words beginning with the letters 'F', 'A' and 'S', excluding proper nouns, numbers and derivatives. After each prompt, subjects must produce as many words as possible within a sixty second period. Both total number of correct responses and total number of errors (e.g. repetitions and intrusions) were recorded.

5. Trail-Making A and B (Army Individual Test Battery, 1944) both test attention, concentration and psychomotor speed, whilst Trails B requires the ability to shift cognitive

set and to inhibit inappropriate responding. Trails B is therefore a measure of executive function. In the case of Trails B, a few patients found this so difficult that a maximum time limit of 5 minutes (300sec.) was set. If the patient had not finished within the time limit, a ceiling score of 360 seconds was allocated. To give a purer measure of executive function, the psychomotor speed factor was partialled out. To do this, the time taken to complete Trails A was subtracted from the time taken to complete Trails B. Thus, the measure of executive function is hereafter referred to as TrailsB-A.

6. The other measure of executive function employed was the 'Name the Ink Colour' version of the Stroop test (Trenerry, Crosson, DeBoe and Leber, 1989). That is, subjects were required to read out the colour of the ink in which a list of colour words were written. Performance on this test requires the ability to inhibit inappropriate responses. Subjects were given two minutes to read as many of the 112 items as possible, and the number read out correctly was recorded.

2.2.2 Measures of mood state

Subjects were also asked to fill in two questionnaires to determine the level of anxiety and depression at the time of testing.

1. The Spielberger State Anxiety Inventory (Spielberger et al., 1972) is a self-rating scale in which subjects are required to rate statements such as 'I feel calm' and 'I am tense' on a scale of 1 (not at all) to 4 (very much so).

2. The Befindlichskeitskala (von Zerssen, Strian and Schwartz, 1974) is another self-rating mood scale generally used to measure diurnal variation in depression. Subjects are presented with 28 pairs of words and required to decide which of the two corresponds most closely to their present state of mind (e.g. alert versus listless; cheerful versus downcast and blue).

2.2.3 Mental State

Mental state was assessed in the schizophrenic group using the Krawiecka Psychiatric Assessment Scale for rating psychotic patients (Krawiecka et al, 1977). The scale gives eight variables: depression, anxiety, delusions, hallucinations, incoherence of speech, flattened/incongruous affect, psychomotor slowness and poverty of speech. Each variable is rated on a five-point scale 0 - 4. Several patients denied any positive symptoms during the interview. In these cases, the ratings were discussed with a charge nurse. If the nurse had observed what he/she considered to be delusional, hallucinatory or thought-disordered behaviour over the past week, the nurses' ratings were used. The sum of the variable scores was used as a measure of severity of illness (Ktotal).

2.2.4 Motivation and co-operation

Motivation and co-operation were assessed using a five-point scale (Shakow, 1981) where a rating of 1 is given in cases of absolute refusal to participate and a rating of 5 given where maximum effort was exerted. Given the subjectivity involved, this is clearly a very crude measure. In practice, the four patients scoring less than four dropped out of the

assessment before sufficient data could be collected to include their results in the analysis. All the remaining subjects received a rating of either four or five.

2.2.5 Ethical approval

The research protocol received ethical approval from the Ethics Committee for Psychiatry and Clinical Psychology of the Lothian Health Board and from the Forth Valley Ethics of Research Committee.

2.3 Statistics

The comparability of the patient group with the controls was examined for age, sex, education, social class, DepCat, anxiety and depression using the appropriate cross-sectional statistic (t-test for two independent samples, chi-square or Mann Whitney U-test). Pearson correlations were then used to determine whether any of the demographic variables, medication, chronicity of illness, severity of illness or the state measures of anxiety and depression correlated with the neuropsychological measures.

Significant differences between patient group and controls on the neuropsychological tests were examined using MANOVA, before and after controlling for covariates. To determine whether the observed impairments in the schizophrenic group were specific or generalised, the raw test scores were transformed to standard equivalents (*z* scores) using the difference between the group means and the standard deviation (SD) of the normal control group. This procedure, described by Saykin et al (1991), attempts to provide comparability across

tests. In order to take account of the effect of the covariates, this analysis was then repeated using adjusted means.

Two factor analyses were then carried out. The first was used to determine whether the neuropsychological tests used clustered together as suggested by factor analytic studies in normal, brain-damaged and psychiatric populations (e.g. Shelly and Goldstein, 1982; Swiercinsky and Howard, 1983; Ernst, Warner, Hochberg and Townes, 1988). That is, executive function and memory tests were expected to emerge as separate factors. Initial factors were extracted using the method of principal components followed by a Varimax rotation.

The second factor analysis examined the segregation of schizophrenic symptoms. Initial factors were extracted by the method of principal components. Following Liddle (1987), oblimin rotation was then performed because there is no *a priori* reason why factors representing different schizophrenic syndromes should be orthogonal. Pearson correlations between factor scores and neuropsychological measures were then calculated.

All the data analyses were carried out using SPSS for Windows Version 6.1.

3.0 RESULTS

3.1 Between-group differences on demographic variables

The first aim was to determine whether there were significant differences among the two groups on demographic variables (see Table 1). Using t-tests for independent samples, it was found that age ($p < 0.01$) and years in full-time education ($p < 0.001$) differed significantly. Using Mann-Whitney U-tests, social class ($Z = -3.31$; $p < 0.001$) and DepCat ($Z = -3.00$; $p < 0.01$) also significantly differed. Social class and DepCat were highly correlated using Spearman's correlation coefficient ($r = 0.62$; $p < 0.001$). Given their close relationship, only DepCat was used in subsequent analyses as a measure of social-economic status. A chi-square test demonstrated that sex did not differ significantly between the two groups (chi-square = 3.21; $p = 0.07$).

3.2 Between-group differences on measures of mood state

Interestingly, whilst the level of anxiety at the time of testing as measured by the Spielberger State Anxiety Inventory (S-SAI) differed between the two groups, the level of depressed mood at the time of testing as measured by the Befindlichskeitskala (BFS) was not significantly different (see Table 1). There was, though, a trend for the schizophrenic group to report being more depressed.

Table 1: Between - group differences

Table 1 illustrates t-tests for independent samples unless otherwise indicated.

* = Mann Whitney U-test ** = Chi-square test

	Schizophrenic patients		Controls		p
	Mean	S.D.	Mean	S.D.	
Age	42.02	13.32	32.00	10.31	< 0.01
Education	12.63	1.917	14.65	2.48	< 0.001
S - SAI	23.63	14.90	14.15	8.816	< 0.01
BFS	10.20	8.65	6.90	6.19	0.10
DepCat*	4.20	1.93	2.60	1.39	< 0.001
SES*	3.55	1.08	2.55	0.76	< 0.01
Sex**	1.23	0.42	1.45	0.51	0.07

S-SAI = Spielberger State Anxiety Inventory BFS = Befindlichskeitskala

DepCat = Deprivation Category SES = Social Economic Status

3.3 Anxiety and depression at the time of testing will explain a significant proportion of the observed variance in the neuropsychological test performance of patients with schizophrenia (hypothesis 1)

Neither anxiety nor depression at the time of testing correlated with any of the test results. This was true for both groups combined and for the patient group and the control group individually (see Tables 2a,bi, ii and c). The main hypothesis that anxiety and depression at the time of testing would explain a significant proportion of the observed variance in the neuropsychological test performance of patients with schizophrenia was therefore not supported.

3.4 Other factors associated with neuropsychological test performance

Age and education were significantly correlated with test performance on the majority of the neuropsychological tests for the total sample and the schizophrenic group (Tables 2a and 2bi). In the latter group, DepCat was significantly correlated only with Speed of Comprehension, Stroop, Trails B-A and Trails A. In Table 2bii, chronicity of illness was significantly correlated with cognitive test performance on the majority of tests, but itself was highly correlated with age ($r = 0.83$; $p < 0.001$) and it is suggested that the age of the subjects might be the potent factor explaining the correlations. Neither antipsychotic medication dosage nor the severity of illness correlated with neuropsychological performance in the schizophrenic sample. It should be noted that chlorpromazine equivalents were only available for eighteen of the forty patients. Table 2bii also presents

the results of a series of t-tests describing how neuropsychological performance was affected by the presence or absence of anticholinergic medication. With the exception of the Stroop test and the Speed of Comprehension test, there were no significant differences on neuropsychological performance between those who had been prescribed anticholinergics and those who were not taking such medication. The findings that antipsychotic medication dosage did not correlate with neuropsychological test performance, and that there were no effects of anticholinergic medication on the majority of the tests, were somewhat surprising given the known effects of these sorts of medication on cognitive test performance. However, it should be noted that Saykin et al (1994) had found substantial cognitive impairments in first episode, neuroleptic-naive patients, a finding which strongly suggests that the presence of cognitive impairments in patients with schizophrenia cannot be solely attributable to medication effects. In the normal control group, age, education and DepCat did not correlate significantly with the majority of cognitive tests, as illustrated in Table 2c.

Table 2a

Correlates of total sample cognitive test performance

	S-SAI	BFS	Age	Education	DepCat
CVLT1-5	-0.10	0.02	-0.44**	0.36**	-0.44**
CVLTDelay	-0.14	-0.07	-0.42**	0.49**	-0.39**
CVLTRecog	-0.14	-0.11	-0.20	0.24	-0.05
Speed of Comp	-0.07	0.01	-0.48**	-0.40**	0.46**
Orientation	0.11	0.07	-0.40**	0.46**	-0.30*
FAS	-0.03	0.02	-0.33**	0.45**	-0.34**
STROOP	-0.11	-0.01	-0.59**	0.56**	-0.52**
TrailsB-A	0.08	0.01	0.48**	-0.52**	0.45**
TrailsA	0.03	0.03	0.62**	-0.48**	0.47**

* $P < 0.05$; ** $P < 0.01$.

Pearson's correlation matrix of correlates of total sample cognitive test performance.

CVLT1 - 5 = California Verbal Learning Test sum of trials 1 - 5.

CVLTDelay = California Verbal Learning Test delay trial.

CVLTRecog = California Verbal Learning Test delayed recognition trial.

Speed of Comp = Number of items correct on a two minute trial of the Speed of Comprehension test.

Orientation = Orientation subscale from the Rivermead Behavioural Memory Test

FAS = Sum of correct three one-minute trials of verbal fluency.

STROOP = Number of correct identifications of colour ink on the Stroop

TrailsB-A = Time taken to complete Trails B minus time taken to complete Trails ATrails A = Time taken to complete Trails A.

Table 2bi

Correlates of schizophrenic cognitive test performance

	S-SAI	BFS	Age	Educ	DepCat
CVLT1-5	0.13	0.23	-0.49**	0.42**	-0.23
CVLTDelay	0.16	0.09	-0.43**	0.55**	-0.22
CVLTRecog	-0.03	-0.06	-0.17	0.19	0.10
Speed of Comp	0.23	0.19	-0.42**	-0.30	0.38*
Orientation	0.22	0.12	-0.36*	0.48**	-0.27
FAS	0.17	0.14	-0.39*	0.53**	-0.30
STROOP	0.16	0.19	-0.56**	0.58**	-0.43**
TrailsB-A	-0.15	-0.16	0.43**	-0.55**	0.33*
TrailsA	-0.16	-0.07	0.59**	-0.47**	0.41**

*, $P < 0.05$; **$P < 0.01$.

Pearson's correlation matrix of correlates of schizophrenic cognitive test performance.

Table 2bii

Correlates of schizophrenic cognitive test performance (continued)

	Meds 1 (n = 18)	Chron	Ktotal	Meds 2 (#)
CVLT1-5	-0.00	-0.49**	-0.25	0.76
CVLTDelay	-0.09	-0.36*	-0.21	0.87
CVLTRecog	0.06	0.09	-0.11	0.64
Speed of Comp	0.42	-0.32*	-0.31	<0.05
Orientation	0.12	-0.39*	-0.13	0.08
FAS	0.39	-0.19	-0.10	0.73
STROOP	0.32	-0.47**	-0.29	<0.05
TrailsB-A	-0.09	0.33*	-0.09	0.08
Trails A	-0.20	0.50**	-0.20	0.12

*, $P < 0.05$; **$P < 0.01$.

Pearson's correlation matrix of correlates of schizophrenic cognitive test performance.

Data = p values for a between-group comparison using t-tests for independent samples

Meds 1 = Chlorpromazine equivalents.

Meds 2 = Presence/Absence of anticholinergic medication.

Chron = Chronicity in years.

Ktotal = Total score on Krawiecka Psychiatric Assessment Scale (severity of illness).

Table 2c

Correlates of normal controls' cognitive test performance

	S-SAI	BFS	Age	Education	DepCat
CVLT1-5	0.11	0.03	0.09	-0.18	-0.47*
CVLTDelay	-0.17	0.04	0.33	-0.14	-0.09
CVLTRecog	-0.18	0.01	0.33	-0.00	-0.06
Speed of Comp	0.07	0.14	-0.19	0.04	0.13
Orientation	0.28	0.24	-0.27	0.37	0.27
FAS	0.06	0.09	0.16	0.08	-0.01
STROOP	-0.16	-0.08	-0.23	0.05	0.00
TrailsB-A	0.09	0.33	-0.12	0.20	0.11
TrailsA	-0.23	0.02	0.65**	-0.25	-0.09

*, $P < 0.05$; **$P < 0.01$.

Pearson's correlation matrix of correlates of normal controls' cognitive test performance.

3.5 Between-group differences on neuropsychological test performance

Next, a MANOVA was carried out to determine whether there were significant between-group differences on the cognitive measures. It was found that there was an overall significant between-group difference on neuropsychological test performance ($F = 7.33$; $p < 0.001$). Furthermore, all the univariate analyses showed a significant difference between the patients with schizophrenia and the normal control group as illustrated in Table 3. On

the other hand, it was noted that, contrary to the findings of Tamlyn et al (1992), schizophrenic subjects did not make an increased number of errors on the Speed of Comprehension test compared to normal controls ($p = 0.14$) although their finding of semantic slowing was replicated.

Table 3

Univariate analyses of between-group differences on neuropsychological performance

Univariate F-tests with (1,58) D. F.

	Schizophrenic patients		**Healthy controls**		**F**	**p**
	Mean	**S.D.**	**Mean**	**S.D.**		
CVLT1-5	35.05	10.16	50.80	12.00	28.41	<0.001
CVLTDelay	6.85	2.84	11.50	2.19	5.43	<0.05
CVLTRecog	13.70	2.84	15.25	1.21	41.18	<0.001
Speed of Comp	38.66	22.39	78.20	24.00	39.61	<0.001
Orientation	9.40	0.98	9.90	0.31	4.91	<0.05
FAS	30.53	15.06	47.80	19.44	14.39	<0.001
STROOP	63.60	28.06	105.45	10.14	41.47	<0.001
TrailsB-A	105.38	69.89	26.75	13.82	24.63	<0.001
TrailsA	71.96	54.27	29.45	9.43	12.00	<0.001

However, given that age, education and DepCat were all found to correlate with the majority of cognitive measures, it was necessary to carry out a multivariate analysis of variance to control for these variables (see Table 4). There are well recognised associations between age, years in full-time education, social-economic status and cognitive test performance (e.g. Lezak, 1995). It was found that, overall, significant group differences remained on cognitive test performance ($F = 3.90$; $p < 0.001$). Univariate analyses showed that significant group differences remained on the learning and delayed recall trials of the California Verbal Learning Test, the Speed of Comprehension test, the Stroop test and Trails B-A at $p < 0.01$ and on Controlled Oral Word Association at $p < 0.05$. That is, there were significant between-group differences on indices of learning and delayed recall (aspects of episodic memory), and measures of semantic memory and executive function. There were no between-group differences on measures of psychomotor speed, orientation nor recognition memory after age, education and social-economic status had been taken into account.

Table 4

Multivariate analysis of variance showing between-group differences controlling for age, education and DepCat.

Univariate F-tests with (1,55) D. F.

	Adjusted Means		**F**	**p**
	Schizophrenic patients	**Healthy controls**		
CVLT1-5	37.38	48.48	11.79	<0.001
CVLTDelay	7.41	10.94	19.15	<0.001
CVLTRecog	13.79	15.16	3.12	0.08
Speed of Comp	43.94	72.93	17.86	<0.001
Orientation	9.62	9.69	0.08	0.77
FAS	33.94	44.38	4.22	<0.05
STROOP	72.20	96.85	16.14	<0.001
TrailsB-A	88.22	43.91	7.24	<0.01
TrailsA	56.12	45.31	0.89	0.35

3.6 Cognitive deficits in schizophrenia: generalised versus disproportionate? (hypothesis 2)

The procedure previously described in section 2.3 and by Saykin et al (1991) was followed. The *z* score profile on the neuropsychological assessments for patients' unadjusted scores is shown in Fig 1. The control group mean is represented by the zero line with SD = 1 for all functions. In contrast to Saykin et al (1991, 1994) who demonstrated differential deficits on semantic memory, visual memory and verbal learning functions, the present study found a marked differential deficit on measures of executive function compared to measures of memory. After controlling for age, education and DepCat, the adjusted analyses are illustrated in Fig 2. The disproportionate deficit remains, although the size of the difference decreases substantially.

Fig 1 Neuropsychological profile for unadjusted scores for patients with schizophrenia (n = 40) relative to controls (n = 20) whose performance is set to zero (+/- 1 SD).

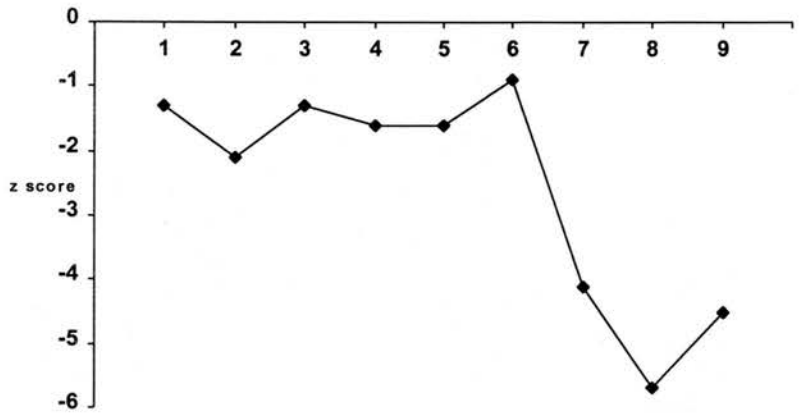
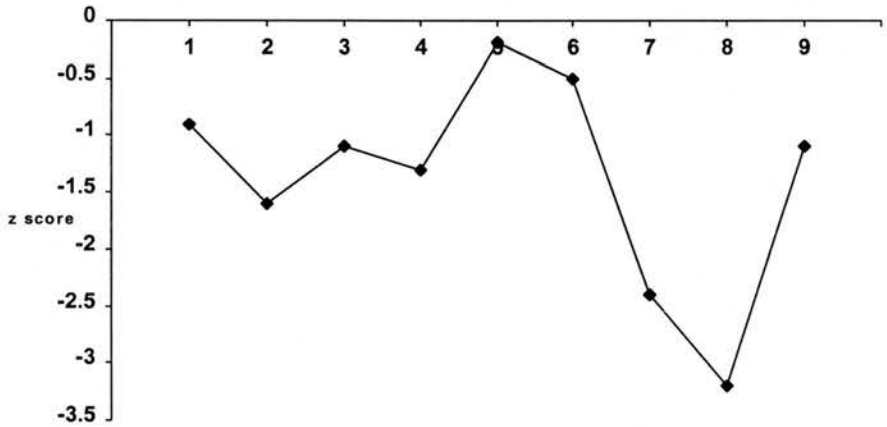


Fig 2 Neuropsychological profile for adjusted scores for patients with schizophrenia (n = 40) relative to controls (n = 20) whose performance is set to zero (+/- 1 SD).



On the x axis, 1 = CVLT Trials(1-5); 2 = CVLT Delayed recall; 3 = CVLT Recognition; 4 = Speed of Comprehension; 5 = Orientation; 6 = Controlled Oral Word Association; 7 = STROOP; 8 = TrailsB-A; 9 = TrailsA.

3.7 Factor analysis of neuropsychological measures

It was hypothesised that the neuropsychological measures would cluster together in differentiating the groups according to the cognitive function they purportedly measured. This was tested using factor analytical methods, with the awareness that it was a small sample on which to carry out factor analysis. Despite the small sample size, there was found to be some clustering of tests together as hypothesised. Factor analysis extracted two factors by the method of principal components followed by a Varimax rotation. The first loaded on Trails A, TrailsB-A, Stroop, Speed of Comprehension and Orientation. The second factor loaded on all the CVLT measures as well as on FAS. Thus, even with such a small sample size there was an observed tendency towards a clustering of memory tests together versus measures of other cognitive functions.

Table 5

Factor loadings derived by factor analysis of neuropsychological measures

	Factor 1	Factor 2
Percentage of total variance explained	**60.4%**	**12.0%**
CVLT1-5	0.50	0.63
CVLTDelay	0.56	0.67
CVLTRecog	0.00	0.86
Speed of Comprehension	0.68	0.49
Orientation	0.83	0.02
FAS	0.33	0.76
STROOP	0.81	0.45
TrailsB-A	-0.74	-0.42
TrailsA	-0.81	-0.20

3.7 Schizophrenic symptoms cluster together in specific syndromes (hypothesis 3)

The next aim of the study was to examine the relationships between schizophrenic symptoms as measured by the Krawiecka Psychiatric Assessment Scale. Again, it should be noted that 40 subjects is a small sample on which to carry out factor analysis. Despite this, three factors were extracted, using the method of principal components followed by an oblimin rotation. Each loaded highly on a separate set of symptoms. In order to include the third factor which accounted for 14.8% of the total variance, the Eigenvalue was set at

0.8. The first factor loaded highly on the subscales of flattened/incongruous affect, poverty of speech and psychomotor poverty, and accounted for 52.0% of the total variance. The second factor, explaining 19.5% of the total variance, loaded on delusions and hallucinations. If the anxiety and depression subscales were added into the analysis, the second factor also loaded on these affective components (see Appendix 2). The third factor loaded only on incoherence of speech (14.8% of the total variance). The three factors delineated in the present study closely resembled what Liddle (1987) designated the psychomotor poverty, the reality distortion and the disorganisation syndromes. The three syndromes found in the present study were, as Liddle had previously found, only weakly correlated. The strongest correlation was between the psychomotor poverty syndrome and the reality distortion syndrome ($r = 0.33$).

Table 6

Factor loadings derived by factor analysis of Krawiecka Psychiatric Assessment Scale

	Factor 1	**Factor 2**	**Factor 3**
Percentage of total variance explained	**52.0%**	**19.5%**	**14.8%**
Flattened Affect	0.80	0.06	-0.32
Poverty of Speech	0.99	-0.07	0.26
Psychomotor Poverty	0.83	0.13	-0.15
Delusions	0.11	0.73	-0.20
Hallucinations	-0.07	0.96	0.14
Incoherence of Speech	0.00	0.00	-0.97

3.8 Correlates of clinical features with neuropsychological tests

Finally, Liddle and Morris (1991) had subsequently proceeded to produce evidence that suggested that the syndromes of psychomotor poverty and disorganisation were associated with distinguishable patterns of executive dysfunction. They claimed that the psychomotor syndrome was correlated with a slowing of mental activity affecting not only the articulation but also the generation of words. Furthermore, the disorganisation syndrome was associated with a difficulty in inhibiting inappropriate responses. Accordingly, the present study carried out a similar investigation. Each factor score used was the cumulative score saved from the factor analysis.

Table 7

Correlations of schizophrenic syndromes with neuropsychological performance

	Psychomotor Poverty	**Reality Distortion**	**Disorganisation**
CVLT1-5	**-0.61****	**-0.46****	**0.32***
CVLTDelay	**-0.63****	**-0.51****	**0.21**
CVLTRecog	**-0.20**	**-0.36****	**0.02**
Speed of Comp	**-0.72****	**-0.47****	**0.29***
Orientation	**-0.47****	**-0.12**	**0.21**
FAS	**-0.51****	**-0.30***	**0.08**
STROOP	**-0.72****	**-0.46****	**0.24**
TrailsB-A	**0.61****	**0.39****	**-0.21**
TrailsA	**0.70****	**0.31**	**-0.7**

*, $p < 0.05$; **, $p < 0.01$

Pearson's correlation matrix of schizophrenic syndrome correlates of cognitive test performance.

As shown in Table 7, the present results did not replicate those of Liddle and Morris (1991). Rather, the psychomotor poverty syndrome was correlated with deficits on all the neuropsychological tests with the exception of the delayed recognition task. The reality distortion syndrome was also correlated with the majority of the cognitive tests, apart from the measure of orientation and Trails A. Thirdly, the incoherence of speech syndrome was correlated only with the verbal learning task, CVLT1-5, and a measure of semantic memory, the Speed of Comprehension test.

4.0 DISCUSSION

The finding that neither state anxiety nor state depression correlated with any of the neuropsychological measures (see Tables 2a, bi,ii and c) does not provide support for the main hypothesis. That is, anxiety and depression at the time of testing were not found to explain a significant proportion of the variance in the neuropsychological impairments observed in patients with schizophrenia. Why this was found to be the case will be discussed in some detail, but first of all it is necessary to question another intriguing result.

4.1 Depression in schizophrenia and healthy controls

It was found that levels of depressed mood at the time of testing did not differ between the schizophrenic group and the normal controls (see Table 1). It is true that there was a trend towards the reporting of higher levels of depressed mood in the schizophrenic group compared to the controls. It may well be that, had the control group been of a comparable size to the schizophrenic group, then this difference would have become significant. Even so, this finding is somewhat surprising given that there is now some consensus that between 40 - 50% of patients suffering from schizophrenia also have symptoms of mild to moderate depression and a further 5 - 10% display symptoms of severe depression (e.g. Markou et al, 1996). In the general population, the lifetime prevalence rates for depression are between 15 - 20% with approximately 12% experiencing depressive symptomatology severe enough to require treatment at some point in their lives (Fennell, 1989). Thus, patients suffering from schizophrenia are more likely to experience depressive symptoms than are controls taken from the general population.

This result would imply one of three things. Either the schizophrenic group were unusual in that they were not particularly depressed, the control group was unusual in experiencing increased levels of depression, or a combination of the two. However, it was noted that at least nine (22.5%) of the patient group were prescribed antidepressant medication whereas none of the control group were taking any form of psychiatric medication. A strong possibility, then, is that the antidepressant medication successfully treated the depressive symptomatology and there were in fact no between-group differences in level of depression at the time of testing.

An alternative suggestion is that the Befindlichskeitskala, one of the measures of state mood employed, was not sensitive to differences in depressed mood. There is good reason to discount this explanation. The instrument has impressive validity and reliability (von Zerssen et al, 1974). It was designed, and has been successfully employed, to measure diurnal variation in depression (e.g. Moffoot et al, 1994). It was noted that the testing of the patients with schizophrenia took place during the day, whereas, on the whole, the testing of the control group took place during the evening. Given that the scale has a subscale for fatigue which was not partialled out in this study, it is possible that the normal control group scored heavily on the fatigue items, thereby inflating their overall depressed mood state rating. It is also possible that whilst the Befindlichskeitskala is sensitive to differences in depressed mood state, it is insensitive to differences in depression. Depressed mood state, after all, is only one aspect of depression.

Yet another explanation for the lack of difference in depressed mood between the patient and control groups is that the schizophrenic patients may have under-reported their symptomatology. The author has frequently observed this in the clinical setting, and

various reasons for this behaviour might be postulated. For example, secondary gains in under-reporting might include fear of medication increases, fear of re-admission to hospital and so on. Although this appeared to be the case for several patients responding to the Krawiecka Psychiatric Assessment Scale (see section 2.2.3), there were significant between-group differences on a measure of anxiety at the time of testing (see Table 1). There is therefore no strong support for the suggestion that the patients with schizophrenia were under-reporting their symptoms on the state measures of mood.

4.1.1 Measures of mood state in psychotic populations

As the lack of a between-group difference was specific to depression, it is possible that instruments used to measure depression are not always suitable for use in a psychotic population. Bentall, Kinderman and Kaney (1994b) argued that deluded patients may have an exaggerated 'self-serving bias' which may be a mechanism for maintaining self-esteem. That is, deluded patients may construct their persecutory hypotheses in order to avoid awareness of discrepancies between how they perceive themselves to be and how they would like to be. The deluded beliefs might have the function of preventing negatively self-referent thoughts from entering consciousness. For example, Bentall and Kaney (1989) found that depressed deluded patients, non-depressed deluded patients and normal controls endorsed as true of themselves far more positive than negative trait words whereas depressed controls endorsed approximately equal numbers of positive and negative trait words. On a recall test, normals recalled more of the positive words endorsed as true, whereas all the patient groups recalled equal numbers of positive and negative words. Furthermore, all the patient groups scored abnormally highly on the Dysfunctional

Attitudes Scale (Weissman and Beck, 1978) which measures beliefs and attitudes defining excessively rigid criteria for evaluating personal performance and self-worth.

It is possible, then, that the Befindlichskeitskala was an unsuitable measure for use in a psychotic population because of this tendency to endorse more positive than negative self-statements. Of course, it could be argued that Bentall and Kaney asked their patients to endorse personality *trait* words whilst the Befindlichskeitskala attempts to measure *state* depression and that therefore different mechanisms are involved. It should also be pointed out that in the present study, the heterogeneous group of patients of schizophrenia were not all deluded at the time of testing. Consistent with this, a wide range of level of depressed mood was reported, again suggesting that not all patients were operating the hypothesised self-serving bias. In summary, it is hypothesised that the Befindlichskeitskala might not have been the most appropriate instrument for measuring mood state in this population. In order to avoid this problem, it is suggested that there is a need for measures of mood state to be developed for used with psychotic patients, that take into account the apparent tendency of patients with schizophrenia to over-endorse positive self-statements.

4.2 Anxiety and depression in schizophrenia and neuropsychological impairments

Returning to the main hypothesis, it was somewhat surprising that the levels of depression and anxiety at the time of testing did not account for a significant proportion of the variance in the neuropsychological impairments observed in the schizophrenic patients (section 3.3). After all, as outlined in the introduction (section 1.3), deficits in immediate and delayed recall, impairment of psychomotor speed and executive dysfunction have all been well-documented in depression (e.g. Austin et al, 1992). These researchers also

found that the more severe the depressive illness, the more profound the cognitive impairment on tests of memory and psychomotor speed. Furthermore, the level of impairment appears to decrease with a reduction in the level of depressed mood, as evidenced by Moffoot et al's (1994) exploitation of diurnal variation of mood. Similarly, Trichard et al (1995) found that impairments of executive function correlate with level of depressed mood. Some degree of executive dysfunction has also been observed in mildly depressed or dysphoric subjects (e.g. Channon, 1996). The evidence for neuropsychological impairments associated with anxiety is less consistent and less well researched. There is some suggestion that patients with a diagnosis of anxiety-based disorder show impaired performance across a wide range of tasks (e.g.Yeudall et al, 1983) and Spielberger (1972) reported that the strongest predictors of performance deficit are measures of immediate mood state rather than measures of trait anxiety.

The present results are consistent with several studies which found only a modest association between emotional variables and impairment on tests of cognitive function in psychiatric patients (e.g. Gass and Daniel, 1990; Caslyn et al, 1982; Gass et al, 1994). It should be noted that these studies used a trait measure of mood rather than a measure of current mood state. Before completely discounting the hypothesis, however, a number of other explanations should be discussed. First of all, it is possible that a number of data outliers confounded the correlations of state anxiety and depression with neuropsychological test performance. However, scatter-plots were constructed for the mood measures against each cognitive measure and this did not appear to be the case (see Appendix 1).

4.2.1 Reactive versus endogenous depression in schizophrenia

An interesting possibility is that the anxiety and depression reported to co-exist in schizophrenia might be qualitatively different from anxiety and depression expressed as distinct disorders. For example, anxiety and/or depression in schizophrenia might reflect a reactive, distressed or helpless response to positive symptoms such as auditory hallucinations. Alternatively, patients' responses on the Spielberger State Anxiety Inventory used in the present study might in fact reflect aspects of paranoia (e.g. "I feel frightened") or even side-effects of medication ("I am jittery") rather than "pure" anxiety symptoms. The same might be argued for items on the Befindlichskeitskala. For example, "alert" versus "listless" might tap into the sedative effects of medication and "sinful and wicked" versus "pure" might reflect the content of auditory hallucinations or delusions. In support of these speculations, when the anxiety and depression subscales of the Krawiecka Psychiatric Assessment Scale were included in the factor analysis of schizophrenic symptoms, they clustered together with the subscales pertaining to hallucinations and delusions (Appendix 2). If this argument is accepted, they lend strength to the case argued above; namely, there is a need for the development of innovative measures of state mood for psychotic patients. Such scales would have to take into account the tendency of patients with schizophrenia to over-endorse positive self-statements. In addition, it would be necessary for the scales to avoid using items that might confound mood state with psychotic symptomatology, medication side-effects and so on. At the very least, there is a clear need for mood rating scales already employed to have norms developed for use with psychotic populations.

There has been interesting research into the nature of depression in schizophrenia. Various hypotheses have been proposed. For example, Falloon, Watt and Shepherd (1978) alleged that neuroleptic drugs have a depressant effect in some patients, particularly certain depot injections. However, Johnson (1981) found that patients maintained in remission on regular depot injections had the lowest prevalence of depression. In addition, Roy, Thompson and Kennedy (1983) found that there was no difference in depression rates between groups for numbers of patients receiving neuroleptics, the mean chloropromazine daily dosage equivalents or the numbers of patients receiving neuroleptics by injection. Roy et al (1983) have also hypothesised that patients with marked negative symptoms are at a higher risk for depression. That is, the presence of negative symptoms may make rehabilitation more difficult as these patients are more socially isolated. Unsuccessful rehabilitation may lead to the patient experiencing a higher incidence of undesirable life events. On the other hand, Johnson (1981) found that depression is present in all stages of the illness, including during the first episode. This would suggest that depression is an intrinsic part of the psychotic illness. An alternative explanation looks to the psychological literature on identity and coping. Birchwood, Mason, MacMillan and Healy (1993) argued convincingly that what concerns schizophrenic patients the most, and is also most closely allied to depression, is thoughts of hopelessness about their illness and its secondary handicaps, engendered by the feeling that their illness is beyond their control. That is, the depressive elements may be a direct response to the schizophrenic patients' life circumstances.

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If this is the case, it could be argued that depression in schizophrenia is in fact a reactive condition rather than an endogenous type of depression. The research into the cognitive impairments associated with depression focuses mostly on major depressive disorder with

patients suffering from marked biological symptoms as well as negative cognitions including hopelessness. It could be that neuropsychological impairments are associated most commonly with the endogenous-type features displayed by patients with major depressive disorder. As Cassens et al (1990) pointed out, "some depressed patients present with few cognitive deficits, some with rather focal or discrete neuropsychological deficits, and some with moderate to severe global deficits" (p.210). As outlined in section 1.3.1.4, they propose a classification of depression based on neuropsychological profile rather than by clinical symptom. The first subtype, it is proposed, are patients with minimal cognitive dysfunction, typically those with "chronic characterological depressions, dysthymic disorders, or reactive depressions" (p.212). Their second subtype is composed of those patients commonly classified as having unipolar depression. Such patients may show both attentional deficits and relatively focal neuropsychological dysfunction. The third subtype is made up of typically older patients who have a 'pseudodementia' type of depression with significant and widespread cognitive impairment. If the depression in schizophrenia is typically a reactive type of depression, then following Cassens et al (1990) one would not expect to find marked cognitive impairments associated with depression in schizophrenia.

The major flaw in this argument is, of course, the finding that the degree of cognitive impairment tends to vary with the level of depressed mood (Moffoot et al, 1994). To account for this factor, it is hypothesised that Cassens et al's (1990) proposed subtypes may represent points along a continuum rather than three distinct syndromes. Along this continuum, schizophrenic depression might fall at the milder end, being a response to the perceived hopelessness of their situation. In addition, this sort of continuum would not exclude more 'endogenous' or non-reactive types of depression from co-existing with

schizophrenia. It could also be hypothesised, using similar arguments, that such a continuum also exists for anxiety and anxiety in schizophrenia.

4.2.2 Between-subject and within-subject designs

A simpler, methodological consideration might also explain the lack of support for the main hypothesis. The vast majority of research into the cognitive impairments that accompany anxiety and depression have employed a between-subject design. Exceptions to this include the ingenious exploitation of diurnal variation in level of depressed mood employed by Moffoot et al (1994) previously described in section 1.3.1.1. There do not, however, appear to have been any studies employing a within-subject design to examine the effect of anxiety on neuropsychological test performance. It is possible, then, that even though *between*-subject variability in anxiety is not related to *between*-subject variability in task performance, it remains to be seen whether *within*-subject variability in anxiety is correlated with *within*-subject variability in task performance. Similarly, with regards to the primary hypothesis of the present study, it remains to be established whether within-subject variability in mood at the time of testing is correlated with within-subject variability on the cognitive measures. This would necessitate each subject completing both the cognitive tests and the state mood measures on two different occasions.

4.2.3 Summary

In conclusion, then, the present findings do not support the hypothesis that anxiety and depression account for a significant proportion of the variance in the neuropsychological impairments observed in schizophrenia. This is in accordance with other studies that have

failed to find emotional correlates of neuropsychological performance in psychiatric patients using trait measures of mood. Three other possibilities remain which merit further investigation. The first is that the usual methods of assessing state anxiety and depression are not appropriate measures to use with a schizophrenic population because many of the items on these instruments may tap into medication side-effects or aspects of positive symptom disturbance. The second is that anxiety and depression in schizophrenia are most frequently of a reactive type. It is suggested that reactive-type mood disturbances may not be commonly associated with significant levels of impairment on the cognitive tests used. Finally, a different area of research in the future might be to use a within-subject, as opposed to a between-subject, design.

4.3 Generalised versus disproportionate cognitive impairments in schizophrenia

The second hypothesis questioned whether there was a specific or generalised cognitive deficit associated with schizophrenia. The literature pertaining to this issue has been previously reviewed in section 1.4. That is, the poor neuropsychological performance typically observed in schizophrenia might reflect a generalised deterioration in cognitive function as proposed by Blanchard and Neale (1994). On the other hand, other researchers have found evidence of generalised impaired performance on neuropsychological tests coupled with further deficits in specific areas of cognitive function. For example, Saykin et al (1991, 1994) found evidence of a specific memory and learning deficit against a background of generalised impairment whilst Shallice et al (1991), using an innovative case-study approach to the neuropsychology of schizophrenia, found that deficits in executive function stood out as being impaired relative to the background level of cognitive functioning. Similarly, Kolb and Wishaw (1983) reported a differential deficit

on cognitive tests of executive function relative to tests measuring other aspects of cognitive functioning.

4.3.1 Schizophrenic and normal subjects' performance on cognitive tests

The present research showed that schizophrenic patients performed worse than healthy controls on all measures of cognitive functioning (Table 3). There were, however, significant differences between the groups on age, years in full-time education and socio-economic status as measured by DepCat (Table 1). These three variables are all known to affect cognitive test performance (e.g. Lezak, 1995). The control group was poorly matched on these variables due to the recruitment method which relied on personal contacts. In future research, it would be preferable to use alternative modes of recruitment such as selection from a GP's patient list.

Antipsychotic and anticholinergic medication were the other obvious differences between the patient group and the control group. Although these medications are known to have at least a mild effect on cognitive functioning (e.g. Spohn and Strauss, 1989; Frith, 1984), in the present study antipsychotic medication was not correlated with neuropsychological functioning. Furthermore, there were no differences on the cognitive measures between those patients who were prescribed anticholinergic medication and those who were not (see Table 2bii). This suggested that their effect on neuropsychological performance was not a significant variable.

Even having controlled for the variables of age, education and social-economic status, there remained significant differences between the schizophrenic group and the control

group on the majority of the cognitive measures (Table 4). Significant differences were found for learning and delayed recall of a list of words and for a measure of semantic memory, replicating the results of Tamlyn et al (1992) and Duffy and O'Carroll (1994). There were also significant differences on a test of verbal fluency and two other tests of executive function requiring the ability to shift cognitive set and to inhibit inappropriate responding in line with the findings of others such as Shallice et al (1991).

No significant differences were demonstrated on recognition memory, a measure of orientation or a test of psychomotor speed. It could be hypothesised that those patients who were most likely to score poorly on a measure of orientation were those patients who, at the time of testing, were actively psychotic and displaying florid symptoms. The lack of a between-group difference on the orientation measure perhaps reflects the fact that only two of the forty subjects (5%) were recruited from acute wards (see section 2.1.1). It would also be expected that severely ill patients would find it difficult to complete the neuropsychological testing session. However, severity of illness at the time of testing, as measured by the total score on the Krawiecka Psychiatric Assessment Scale (Krawiecka et al, 1977), did not correlate with any of the neuropsychological measures (see Table 2bii). More surprising is the fact that patients with schizophrenia and healthy controls did not differ on a measure of psychomotor speed. Many of the patients had prominent negative symptoms which would be expected to have a pronounced effect on a test of psychomotor speed. The lack of a difference probably reflects the fact that such tests are particularly sensitive to the effects of age (Lezak, 1995) and that perhaps much of the variance was accounted for by this factor rather than by group differences.

4.3.1.1 Semantic errors and semantic slowing in schizophrenia

An interesting side question is why the present study did not find that patients with schizophrenia made significantly more errors than healthy controls on the test of semantic memory, the Speed of Comprehension Test (section 3.5). Two previous studies, Tamlyn et al (1992) and Duffy and O'Carroll (1994), had found a significant between-group difference on the number of errors made using a related measure, the 'Silly Sentences' test. The difference between the procedure used by these two studies and that used by the current research is that the former used speed of verification time per sentence averaged over fifty sentences read aloud to the subjects as the measure of integrity of semantic memory. The present study required patients to endorse in writing as true or false as many as possible of one hundred statements which they read themselves. It is difficult to see why this difference in procedure would cause patients suffering from schizophrenia to make a greater or lesser number of semantic errors. Tamlyn et al (1992) and Duffy and O'Carroll (1994) and the present study all found between-group differences on their main measure of semantic memory using either the Silly Sentences Test or the Speed of Comprehension Test. It is suggested, however, that a difference in error-making might possibly be explained by arguing that patients misinterpret auditory semantic content but not written semantic content of sentences. McKenna (1991) hypothesises that delusions arise as a result of a faulty laying down of new semantic memories. This process could well involve the misinterpretation of auditory information. Alternatively, the misinterpretation of auditory content might well partially explain the phenomena of auditory hallucinations, at least for some patients. These speculations merit further investigation, beginning with a replication of the present finding that schizophrenic

patients do not make more semantic errors than normal controls when reading but only when listening to sentences read aloud.

4.3.2 Disproportionate deficit in executive function

Previous findings that patients suffering from schizophrenia are impaired on measures of learning and memory and executive function were therefore replicated. Of more interest was the present finding that there appeared to be a differential deficit on tests of executive function against a background of more generalised cognitive impairment before and after controlling for potential confounding variables (see Figs 1 and 2). An immediate objection to this claim is that the specific deficit was confined to the schizophrenic subjects' poor performance on the TrailsB-A measure (3.2 SD's below the normal controls' set mean of zero) and the Stroop test (2.4 SD's below). The patients' performance on the Controlled Word Association test, also claimed to be a test of executive function, resembled their performance on the other cognitive measures (0.5 SD's below).

It must be pointed out at this juncture that measures of what is generically described as 'executive function' in fact reflect many different cognitive abilities. TrailsB-A and the Stroop test both require the ability to inhibit inappropriate responses with TrailsB-A also requiring the ability to shift cognitive set. It would appear that the test of verbal fluency also requires the ability to inhibit inappropriate responses to a certain extent as subjects must inhibit proper nouns, derivatives and numbers as well as interference from previous trials of the test. In this study, though, a post hoc analysis of variance revealed that there were no between-group differences on a measure of the number of errors made on the Controlled Word Association Test (see Appendix 3). On the other hand, this measure also

involves the ability to conduct mental searches, another process typically described as an executive function. One possibility, therefore, is that TrailsB-A and the Stroop test measure one particular aspect of executive function whilst the Controlled Word Association Test measures a different aspect.

There is another possibility. It is suggested that the test is also one of the ability to generate words, drawing upon verbal ability and more specifically reflecting verbal or semantic memory. Other researchers (e.g. Ilsley et al, 1995) have employed the Controlled Word Association Test as a measure of semantic memory. It is also of note that when a factor analysis of the neuropsychological test results were carried out, the Controlled Word Association Test clustered together with the California Verbal Learning Test indices rather than the other tests of executive function (Table 5). It is suggested that the test of verbal fluency at least measures a different aspect of executive function to the two other tests employed. Furthermore, it is suggested that good performance on the Controlled Word Association Test also relies on a relatively intact semantic memory system.

4.3.3 Executive function and brain function

Neuropsychological tests of executive function are frequently alleged to be sensitive to the effects of frontal lobe function. If this assumption is accepted, the finding of a selective deficit in executive function is consistent with hypotheses of regional brain function that postulate the frontal lobes to be the primary site of dysfunction in schizophrenia. For example, Kolb and Wishaw (1983) claimed that their finding of a selective executive function deficit in a group of heterogeneous schizophrenic patients was consistent with bilateral frontal and temporal lobe dysfunction. Furthermore, Weinberger (1987) proposed

that the dorsolateral prefrontal cortex was heavily implicated in the pathogenesis of schizophrenia.

Attempts to provide causal explanations for schizophrenic symptoms in terms of brain site dysfunction are, however, fraught with danger. In accordance with O'Carroll (1992) and Frith (1992), it is argued that it is essential to remain within one level of explanation when describing the many facets of schizophrenia. Thus, it is more fruitful to provide a description of schizophrenic abnormalities at a psychological level. It may then be possible to provide a specification of how this psychological description maps onto schizophrenic abnormalities at a physiological level. Frith's (1992) theory, described in section 1.2.2, concerning the cognitive neuropsychology of schizophrenia does exactly this. It is hypothesised that the present findings provide at least partial support for certain aspects of this theory.

4.3.4 Executive function and cognitive neuropsychological models of schizophrenia

To recapitulate, Frith (1992) proposed that a defect in a general mechanism fundamental to conscious experience, which he termed metarepresentation, could explain all the cognitive abnormalities underlying the signs and symptoms of schizophrenia. He proposes that there are three such principal cognitive abnormalities. Firstly, an inability to monitor spontaneous actions may manifest itself as behavioural abnormalities such as poverty of action, perseveration and inappropriate action. Secondly, an inability to monitor willed intentions might lead to positive symptoms such as delusions of alien control, certain auditory hallucinations and thought insertion. Finally, an inability to monitor the beliefs

and intentions of others might lead to delusions of reference, paranoid delusions, certain kinds of incoherence and third person hallucinations.

How, then, does the finding of a selective deficit in executive function provide support for such a theory? Normal executive functioning allows an organism to respond and adapt appropriately to its environment. The cognitive processes that enable the organism to do this include the preparation and execution of action, the initiation and modulation of activity level and the integration of behaviours into purposeful activity. That is, executive function is generally maintained to involve activities such as planning, search, implementation and monitoring. Such processes are integral to Frith's (1992) theory. For example, with respect to the behavioural abnormalities of schizophrenia (including incoherence of speech and incongruity of affect as well as the more traditional 'negative symptoms'), Frith adopts the Supervisory Attentional System (SAS) postulated by Shallice (1988) which "normally modulates the performance of a lower level system that controls the production of routine actions" (p.114, Frith, 1992). If this modulation is disrupted in some way, goals and plans may fail to generate intentions resulting in poverty of action; goals may fail to inhibit actions elicited in response to environmental stimuli resulting in incoherence of action or speech and willed intentions might fail to generate actions resulting in perseveration. The two classes of positive symptoms hypothesised by Frith (1992) also rely heavily on a disruption of ability of the subject to monitor its own willed intentions (resulting in, for example, delusions of alien control, thought insertion and certain auditory hallucinations) as well as to monitor the beliefs and intentions of others (resulting in paranoid delusions, delusions of reference, certain kinds of incoherence and third person hallucinations). At the heart of Frith's cognitive neuropsychological model of schizophrenia, then, are impairment of executive-type functions.

Gray et al's (1991) model focuses on memory but also heavily implicates executive-type functions. Specifically, they describe "a failure in acute schizophrenia to integrate stored memories of past regularities of perceptual input with ongoing motor programmes in the control of current perception" (p.1). There is no doubt, though, that the behavioural inhibition system they describe, whose faulty processing accounts for the expression of positive symptoms, is intended to carry out functions generally maintained to be executive in nature. Its principal role, after all, is to compare actual environmental cues to expected stimuli. The finding of a disproportionate deficit in executive function is arguably consistent with either of the two influential models proposed by Gray et al (1991) and Frith (1992).

It is therefore necessary to examine the specific hypotheses made by each model. As already pointed out, executive functions are many and varied in nature. It might be more fruitful to examine more closely the specific nature of the deficits in executive function found in this present study. The two tests of executive function found to be specifically impaired in the present study both required the ability to inhibit inappropriate responding. Frith (1992) specifically hypothesises that the behavioural abnormalities of schizophrenia are best understood in terms of a fundamental defect in the monitoring of willed action resulting either in poverty of action or in some form of failure to inhibit inappropriate responding. Thus, one would expect patients with schizophrenia to demonstrate impaired performance on tasks such as the Stroop Test and TrailsB-A. This was the pattern of responding observed in the present study, confirming this hypothesis. Frith also specifically proposes that this would imply that patients with schizophrenia would demonstrate impaired performance on a test of verbal fluency. This hypothesis was not

supported by the results of the present study. As previously argued, however, it is likely that successful performance on such tests relies heavily on aspects of semantic memory as well as on executive-type search and inhibitory functions. In fact, Frith's (1992) proposals go further. That is, one would expect deficits in tests requiring the inhibition of inappropriate responding to be associated with particular sorts of schizophrenic symptoms. This shall be discussed later in section 4.4.1.

4.3.5 Between-study differences

Different studies have shown different patterns of cognitive impairment in schizophrenia. Some have claimed a specific memory deficit, others a generalised cognitive impairment, and the current study, following Shallice et al's (1991) single-case study approach, has demonstrated a disproportionate deficit in executive function. It is therefore necessary to examine why the various studies have produced differing patterns of results. All the studies recruited patients who encompassed a wide range of chronicity and severity of illness, with the exception of Shallice et al (1991) whose five subjects were all chronic patients. Saykin et al's (1991) subjects were a younger sample as the cut-off point for recruitment to this study was 45 years old, whilst the other studies' cut-off point was between 60 - 70 years. It is possible then that much of the variability in cognitive test performance is attributable to age. As previously described, age was found to correlate highly with test results in the present study. On the other hand, this does not explain why Blanchard and Neale (1994) found generalised cognitive impairment whilst Shallice et al (1991) and the present study found a specific deficit in executive function. Nor do medication effects appear to account for the differences. Both Blanchard and Neale (1994) and Saykin et al (1991) used medication-free patients. In the current study, neither

antipsychotic nor anticholinergic medication was significantly correlated with neuropsychological performance.

4.3.6 Problems with the concept of a disproportionate deficit in executive functioning

Before the finding of a selective deficit in executive function is unquestioningly accepted, it would be wise to heed the warning of Frith (1992). He, along with many other authors such as Liddle (1987), presupposes that different cognitive deficits are associated with different symptoms, signs or syndromes of schizophrenia. If this assumption were to be validated, this would seriously undermine the sort of methodology employed in studies such as the current one. Using a heterogeneous group of patients with schizophrenia will result in a group of patients with potentially large differences in their symptom profile. If different cognitive deficits do underlie different symptoms or syndromes, each patient in the heterogeneous group would therefore be hypothesised to demonstrate a different neuropsychological impairment profile. The mean performance of a heterogeneous group of schizophrenic patients on a battery of cognitive tests might then provide a very misleading picture of the neuropsychological profile associated with schizophrenia. On the other hand, Frith himself suggests that there might be a single, more general, mechanism underlying the cognitive abnormalities observed in schizophrenia, the mechanism he describes as metarepresentation. It is suggested that metarepresentation involves the kind of activities described as executive function, in particular those processes involving the inhibition of inappropriate responses. Thus, whatever each individual's neuropsychological profile reveals, it would be expected that patients with schizophrenia have in common a deficit in executive function preventing the inhibition of inappropriate responses.

Three other factors need to be taken into account when exploring the implications of the alleged finding of a selective deficit in executive function. First of all, methodological differences and varying statistical procedures might account for at least some of the discrepancy observed in the results across the varying studies. This subject has already been referred to in section 1.6.4. As Saykin et al (1991) acknowledge, "consideration of test reliability and task difficulty is important in identification of the selective deficit" (p. 619). In order to avoid the problem of using tasks that were not psychometrically matched, these authors used standardised residualised scores. Nevertheless, even this method is not free from contamination. Chapman and Chapman (1989) caution that this method might be more suited to use with a less impaired population as it does not remove the effects of generalised performance deficit. Unfortunately, as Blanchard and Neale (1994) point out, "aside from the creation of tasks that are psychometrically matched and subsequently validated in neurological populations, no investigation of the neuropsychological functioning of patients with schizophrenia can remove the possible confounding factor of the differential discriminating power of the tasks". They go on to conclude that "sole reliance on neuropsychological batteries may be ill-suited for testing models of differential deficit in schizophrenia" (p. 46).

On a more theoretical level is the second question of whether executive functions can be disassociated from the concept of memory. The phenomenon of "frontal amnesia" provides an illustration of the problems inherent in doing so. Patients with lesions of the frontal lobe typically demonstrate inertia of memory traces leading to proactive interference (Luria, 1980). On the other hand, Janowsky, Shimamura, Kritchevsky and Squire (1989) found that patients with frontal lesions demonstrated poor performance on

the Wisconsin Card Sorting Test (WCST) and verbal fluency but preserved memory functioning. Even this study, however, may not wholly differentiate memory from executive function. As previously discussed, verbal fluency would seem to at least partially measure semantic memory. It is suggested that efficient memory must utilise organisational strategies. That is, executive functions such as organising strategies and regulating goal-directed behaviour must play at least some role in the workings of memory. Impairments in executive function and consequently disruption of the organisational strategies involved in memory might therefore explain why other studies have found that patients in schizophrenia demonstrate specific impairments in learning and memory. This would be true even if, as Saykin et al (1991) state, impairment of executive functions is not the *primary* cause of the memory deficits observed in patients with schizophrenia. Whether the organisational component implicates the frontal lobes or, as Saykin et al (1991) suggest, more posterior left hemisphere dysfunction believed to play a role in the utilisation of semantic systems to encode information, remains to be determined.

A final, and related, issue is the status which executive functioning has now received in the neuropsychological literature. It could almost be argued that 'the executive' has become akin to a modern 'homunculus'. It may now be time to subject this concept to a rigorous level of theoretical analysis. It is hoped that the discussion so far has highlighted the many and varied activities subsumed under the heading of 'executive functioning'. The relationship between such different activities, however, appears to be somewhat ambiguous. Furthermore, if a central 'executive' or monitoring system is presupposed, it is unclear how the monitor itself is regulated. Unfortunately, these sorts of issues extend far beyond the remit of the present discussion.

4.3.5 Summary

In conclusion, the present results suggested that patients with schizophrenia show a disproportionate deficit in executive function relative to measures of learning and memory. More specifically, this deficit would appear to include a difficulty in inhibiting inappropriate responses to stimuli. Any conclusions that can be drawn must be tempered by the methodological and theoretical difficulties inherent to this kind of research. Bearing in mind such issues, the results of the present study would appear to provide at least partial support for the cognitive neuropsychological model proposed by Frith (1992).

4.4 Syndromes in schizophrenia

The results of the present study confirmed those of previous studies which found that the symptoms of patients with schizophrenia clustered together on three psychotic dimensions (see Table 6). Furthermore, the three syndromes segregated in this piece of research closely resembled those found originally by Liddle and Barnes (1990) and subsequently replicated by studies with far larger subject samples (e.g. Johnstone and Frith, 1996; Vazquez-Banquero et al, 1996 and Serretti et al, 1996). That is, the three syndromes which emerged out of the factor analysis were first of all, a psychomotor poverty syndrome made up of the psychomotor poverty, poverty of speech and flattened affect subscales of the Krawiecka scale. The second factor reflected the positive symptoms of delusions and hallucinations, described as a reality distortion syndrome by Liddle and Barnes (1990). If the anxiety and depression subscales of the Krawiecka scale were included in the analysis, they clustered together with delusions and hallucinations (see Appendix 1). Finally, the

third factor loaded highly only on the incoherence of speech subscale. This syndrome corresponded to what Liddle and Barnes (1990) termed the disorganisation syndrome.

There is now therefore considerable agreement between studies with respect to this segregation of symptoms into three independent syndromes. However, a well-known problem with factor analytic studies is that the extracted factors are wholly determined by the measures put into the analysis. On the other hand, this consensus has been reached despite the variety of instruments employed to provide ratings of clinical symptomatology. To date, these include the Krawiecka Psychiatric Assessment Scale, the scales for the assessment of the positive and negative symptoms of schizophrenia (SAPS and SANS, respectively), affective symptom rating scales and the Operational Criteria Checklist, a computerised checklist which generates diagnoses for categories of affective and psychotic disorders used by Serretti et al (1996) in their study of over 1000 schizophrenia spectrum patients. The segregation of schizophrenic symptoms into three main syndromes would therefore appear to be a robust finding.

4.4.1 Schizophrenic syndromes and neuropsychological performance

Large-scale studies of the syndromes associated with schizophrenia have paved the way for more detailed studies of the relationship between schizophrenic syndromes and neuropsychological performance, reviewed in detail in section 1.5.2. Liddle and Morris (1991) found that the psychomotor poverty syndrome was associated, not surprisingly, with slowness of mental activity, as well as with slowness of generating words on a test of verbal fluency. Furthermore, poor performance on the Stroop test, requiring patients to

inhibit an established but inappropriate response, was found to be associated with the disorganisation syndrome. Similarly, Frith et al (1991b) found that incongruity of affect and incoherence of speech were associated with a failure to inhibit inappropriate responses on a Continuous Performance Task.

The present study did not replicate these earlier findings. The psychomotor poverty syndrome was correlated with all the cognitive measures with the exception of the test of delayed recognition memory. Likewise, reality distortion was correlated with performance on all the neuropsychological tests with the exception of the orientation measure and the test of psychomotor speed, TrailsA. Thirdly, the disorganisation syndrome was correlated only with the measure of learning (CVLT1-5) and the Silly Sentences Test, a measure of semantic memory. This disparity in the results of various studies is likely to have a simple explanation. In the earlier studies, the neuropsychological tests used all related to some aspect of executive functioning. Given this, it was not surprising that correlations were found between the two schizophrenic syndromes of disorganisation and psychomotor poverty and tests measuring executive function.

The present study examined the relationship between schizophrenic syndromes and performance on a variety of cognitive measures of learning and memory and executive function. As stated previously, no reliable correlations were found. Similarly, Norman et al (1997a) did not find any evidence of a correlation between the psychomotor syndrome and performance on the Wisconsin Card Sorting Test, allegedly a measure of executive function. Nor did they find support for their hypothesis that the disorganisation syndrome would be particularly correlated with impaired performance on a Design Fluency test and a measure of verbal fluency. Norman et al (1997a) did claim to find evidence of a

correlation between the reality distortion syndrome and measures of learning and memory. Closer examination of the results revealed that these correlations were particularly weak. Correlation of the reality distortion syndrome with the Logical Memory of the Weschler Memory Scale was weakest ($r = -0.19$, $p < 0.05$), and the correlation of the syndrome with the six recall trials on the Rey Auditory Verbal Learning Test was only slightly stronger ($r = -0.22$, $p < 0.05$). Although Norman et al (1997a) claimed that this correlation was specific to verbal, as opposed to visual memory, the correlation of the reality distortion with the Benton Visual Retention Test appeared to be only slightly below that of the tests of verbal memory function ($r = -0.16$; non-significant).

Studies which explore the relationship between schizophrenic syndromes and neuropsychological performance have therefore shown considerable inconsistency. The present findings do not provide support for the hypothesis proposed by Frith (1992), that the positive abnormalities of behaviour (incoherence of speech and incongruity of affect) observed in schizophrenia can be explained in terms of a failure of willed action in which action is determined rather by irrelevant external stimuli. It follows from this prediction that the disorganisation syndrome confirmed in the present study should correlate with those cognitive measures that for successful performance require inhibition of established but inappropriate responses. However, neither the Stroop test nor TrailsB-A correlated with disorganisation, and neither did the test of verbal fluency.

It has already been pointed out that the main difference between the current study and that of Liddle and Morris (1991), among others, was the selection of neuropsychological measures employed. That is, it is suggested that the previous results reflect an artefact of utilising tests that load only on executive function. As was discussed in a previous section,

the discrepancies in results found between studies probably also reflects methodological differences. In particular, different studies have employed varying measures of cognitive function. On the whole, these tests are not psychometrically matched, making it difficult to make comparisons across studies. In addition, the different populations studied, medication effects and other confounding variables discussed earlier in previous sections all apply equally as well to the hypothesis currently under discussion.

4.4.3 Summary

Overall, then, it is difficult to draw any firm conclusions about the relationships between schizophrenic syndromes and neuropsychological performance. The results of the present study have added to the wealth of inconsistent findings, but certainly highlight the necessity to use neuropsychological measures that reflect a wide range of cognitive function in order to avoid artefactual findings. As psychometrically matched cognitive measures are developed, it is hoped that much of the confusion surrounding this area of research will be resolved. Finally, it is suggested that it may prove more useful in the future to study schizophrenic symptoms, rather than the syndromes associated with schizophrenia, in relation to neuropsychological performance. For example, there does not appear to be a theoretical reason why delusions and hallucinations should share identical neuropsychological deficits even if they do cluster together as a schizophrenic syndrome.

4.5 Conclusions

The results of the present study indicated that anxiety and depression at the time of testing did not explain a significant proportion of the variance in the neuropsychological

impairments observed in patients with schizophrenia. This finding is consistent with other studies which have examined the emotional correlates of the neuropsychological performance of psychiatric populations (e.g. Gass and Russell, 1986). On the other hand, the result is somewhat surprising given the comprehensive literature which now documents the cognitive impairments that accompany depression, although the research into the neuropsychological deficits associated with anxiety appears to be more sparse. One possible explanation is that the measures of mood state employed in the current study are not appropriate for use with psychotic patients. Alternatively, research suggests that depression in schizophrenia may represent a response to the perceived hopelessness of schizophrenic patients' life circumstances (e.g. Birchwood et al, 1993). Cassens et al (1990) suggested that depression could be categorised by neuropsychological subtype. It is hypothesised that depression in schizophrenia might not be expected to be associated with significant cognitive impairments because it resembles the mild, reactive type of depression proposed by Cassens et al (1990). Reactive depression is not predicted to be associated with significant levels of cognitive impairment. Finally, it is also suggested that although *between*-subject variability in anxiety and depression at the time of testing is not related to between-subject variability in task performance, it might well be the case that *within*-subject variability in mood state is correlated with within-subject variability in task performance.

Secondly, the results of the present study suggested that the pattern of neuropsychological test performance observed in patients with schizophrenia reflected a disproportionate deficit in executive function against a background of more generalised cognitive impairment. Thus, the findings of Kolb and Wishaw (1983) and Shallice et al (1991) were substantiated. However, this conclusion must be tempered by the knowledge of

methodological difficulties such as the lack of psychometrically matched tasks and the need for a conceptual re-analysis of the concept of executive functioning.

Thirdly, the segregation of schizophrenic symptomatology into specific syndromes found by a number of previous studies (e.g. Liddle and Morris, 1991) was replicated. That is, three syndromes closely resembling those described by Liddle (1987) as the psychomotor poverty, the disorganisation and the reality distortion syndromes emerged from the factor analysis. Contrary to previous claims (e.g. Liddle and Morris, 1991), none of these three syndromes correlated with the predicted pattern of neuropsychological test performance. This difference might well be explained by the fact that the present study included tests of a variety of cognitive functions rather than those that solely reflect aspects of executive functioning. It is further suggested that it might be more profitable to explore the relationships between cognitive deficits and/or brain function and schizophrenic symptoms, rather than syndromes.

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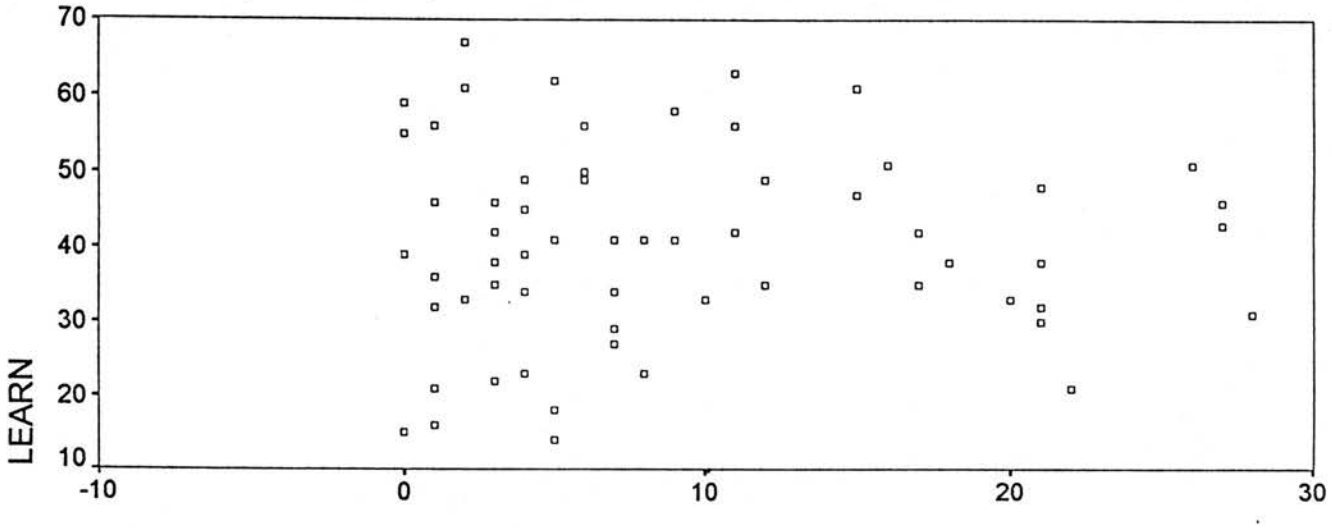
Appendix 1

Scatterplot of depressed mood with CVLT1-5

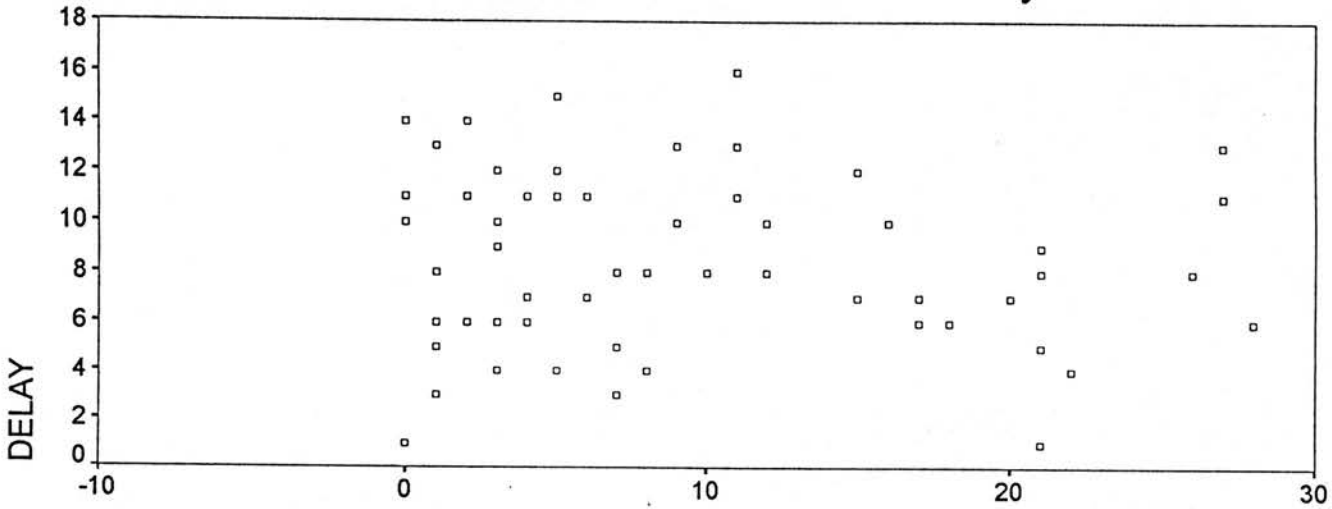


LEARN: Sum of trials 1-5 on the California Verbal Learning Test

BFS: Befindlichskeitskala

Appendix 1

Scatterplot of depressed mood with CVLTDelay

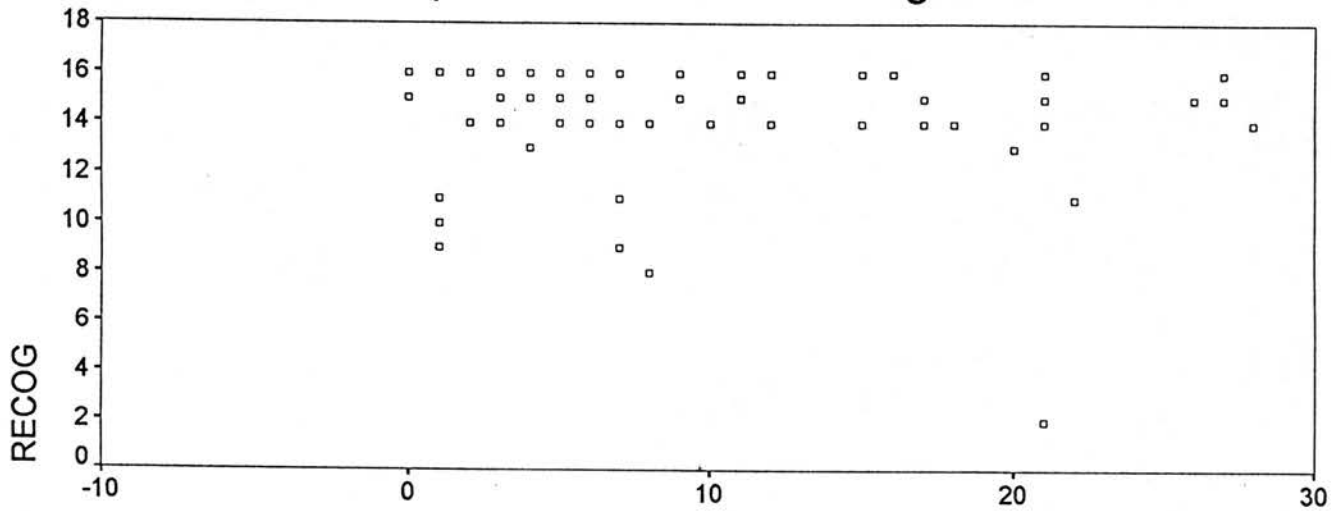


Delay: Delayed recall on the California Verbal Learning Test

BFS: Befindlichskeitskala

Appendix 1

Scatterplot of depressed mood with recognition

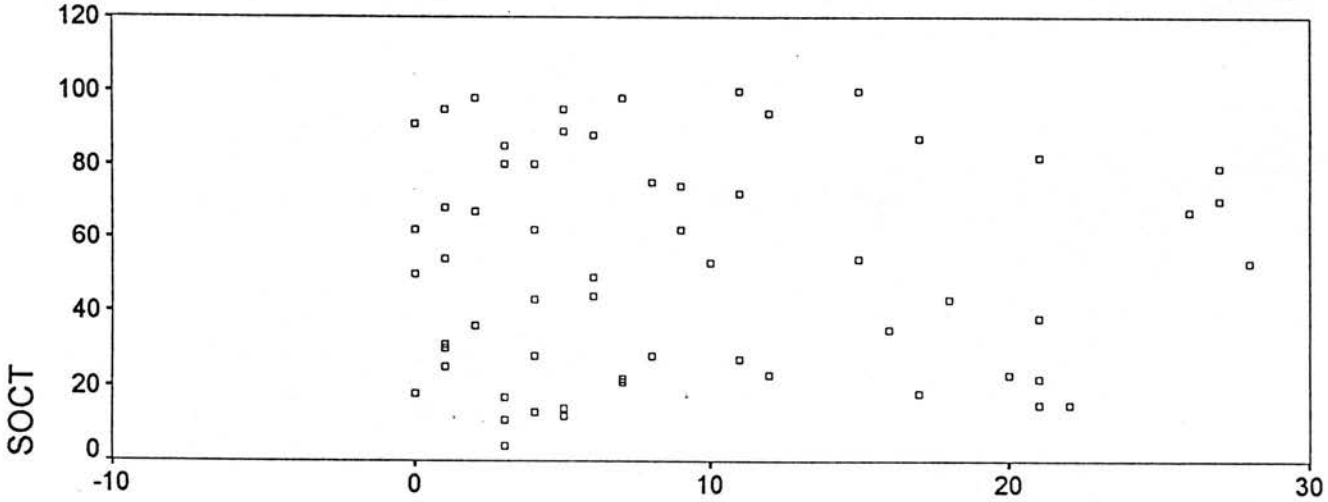


RECOG: Recognition trial of the California Verbal Learning Test

BFS: Befindlichskeitskala

Appendix 1

Scatterplot of depressed mood with speed of comprehension

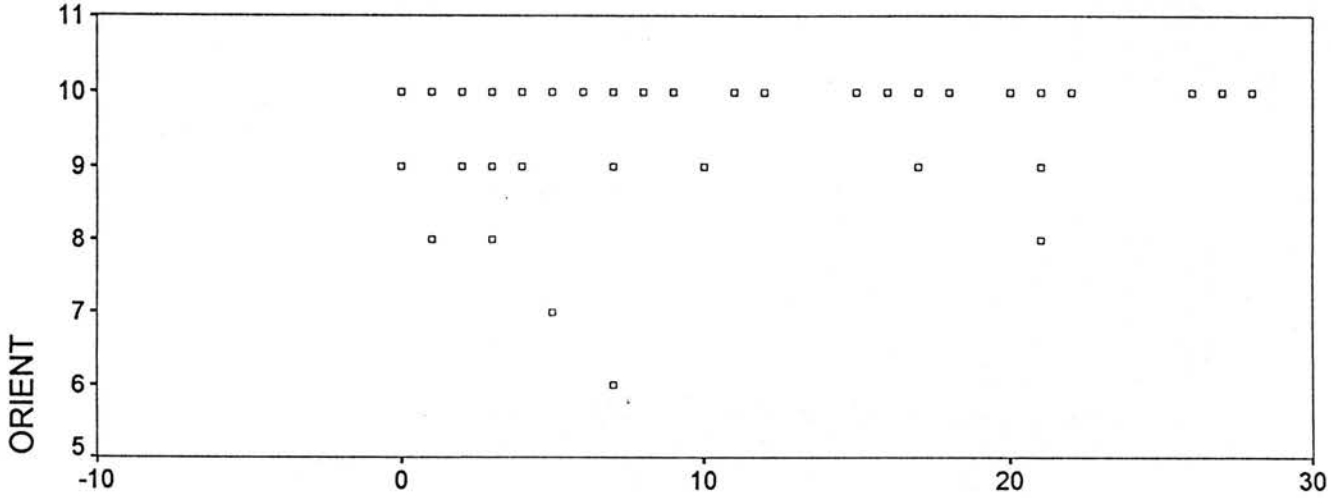


SOCT: Speed of Comprehension Test

BFS: Befindlichskeitskala

Appendix 1

Scatterplot of depressed mood with orientation

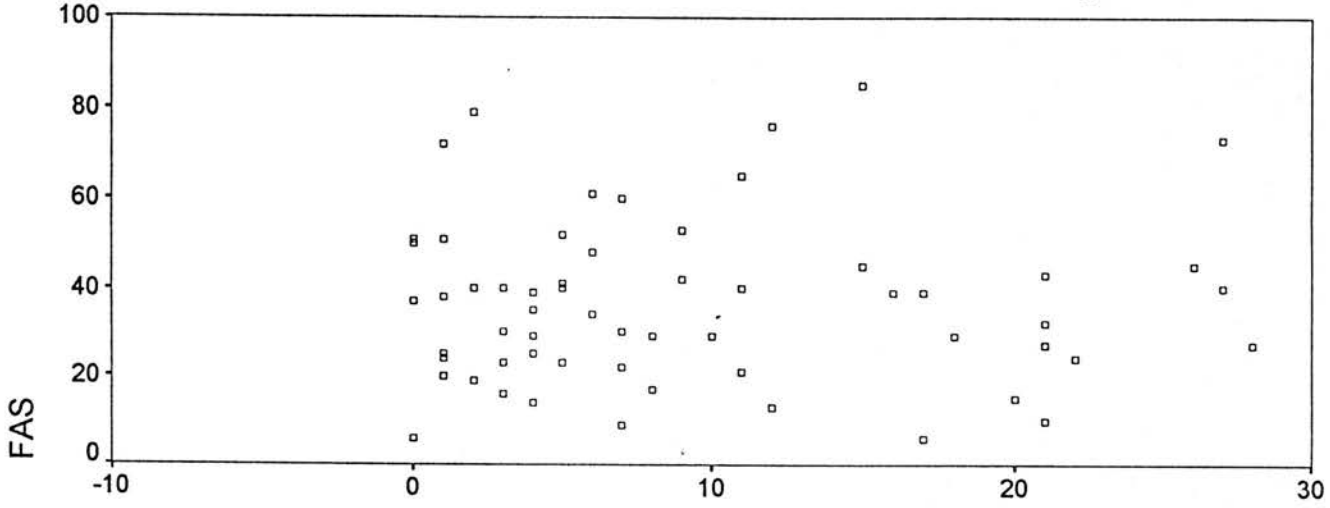


ORIENT: Orientation subscale of the Rivermead Behavioural Memory Test

BFS: Befindlichskeitskala

Appendix 1

Scatterplot of depressed mood with verbal fluency

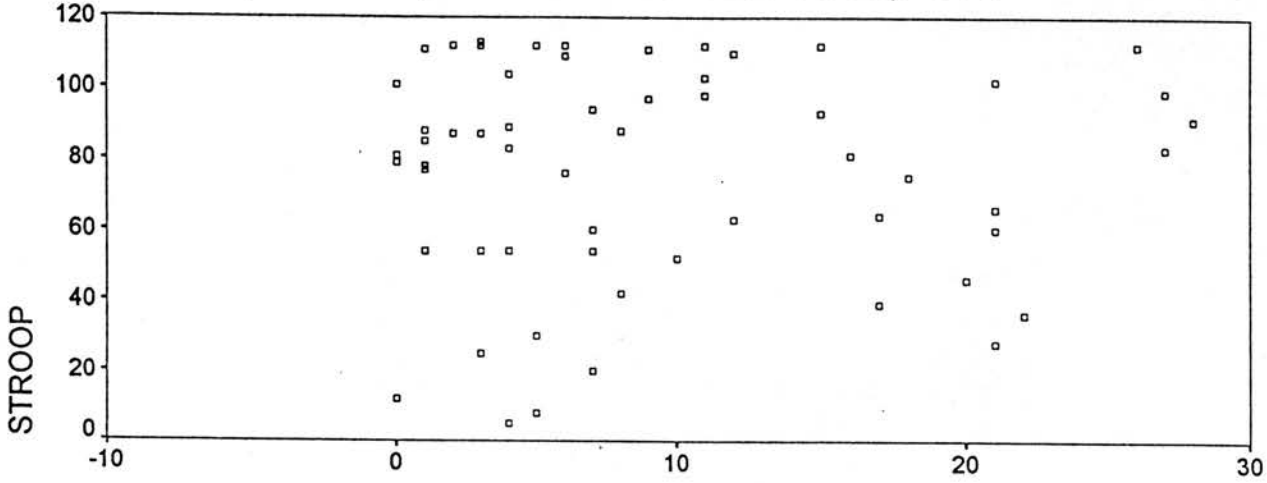


FAS: Controlled Word Association Test

BFS: Befindlichskeitskala

Appendix 1

Scatterplot of depressed mood with Stroop test

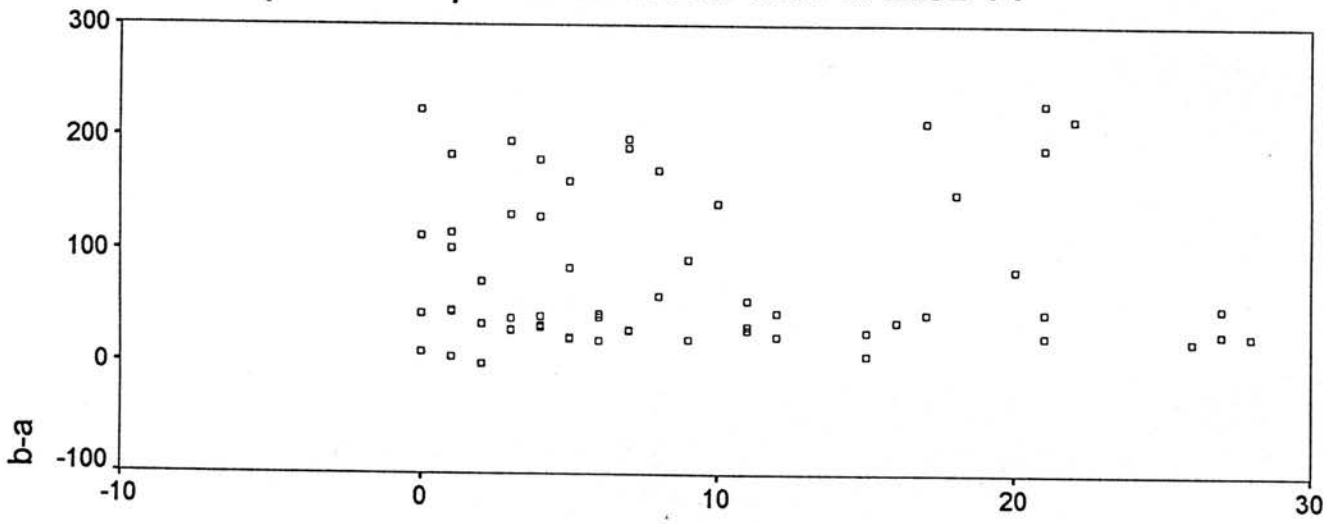


STROOP: Stroop test

BFS: Befindlichskeitskala

Appendix 1

Scatterplot of depressed mood with TrailsB-A

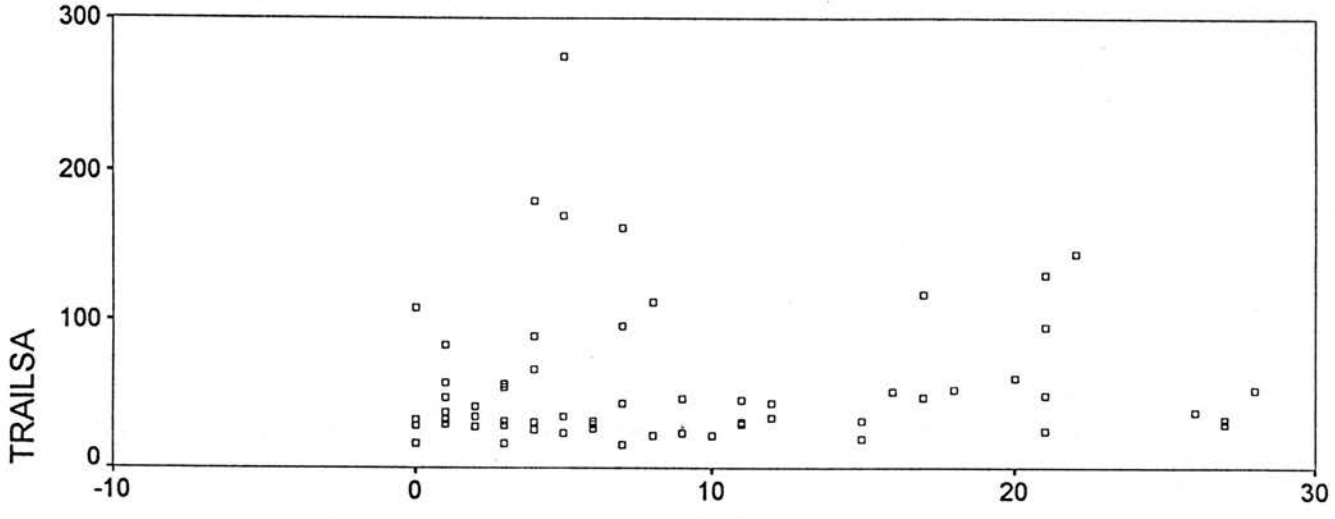


b-a: Time taken to complete TrailsB-A

BFS: Befindlichskeitskala

Appendix 1

Scatterplot of depressed mood with TrailsA

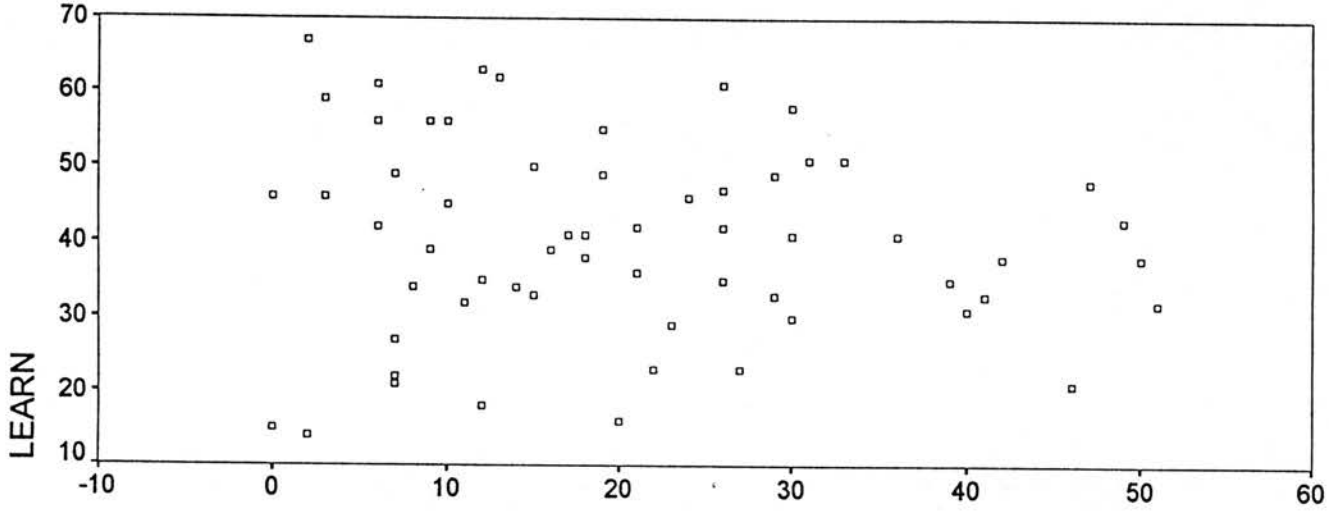


TRAILSA: Time taken on TrailsA

BFS: Befindlichskeitskala

Appendix 1

Scatterplot of anxious mood with CVLT1-5

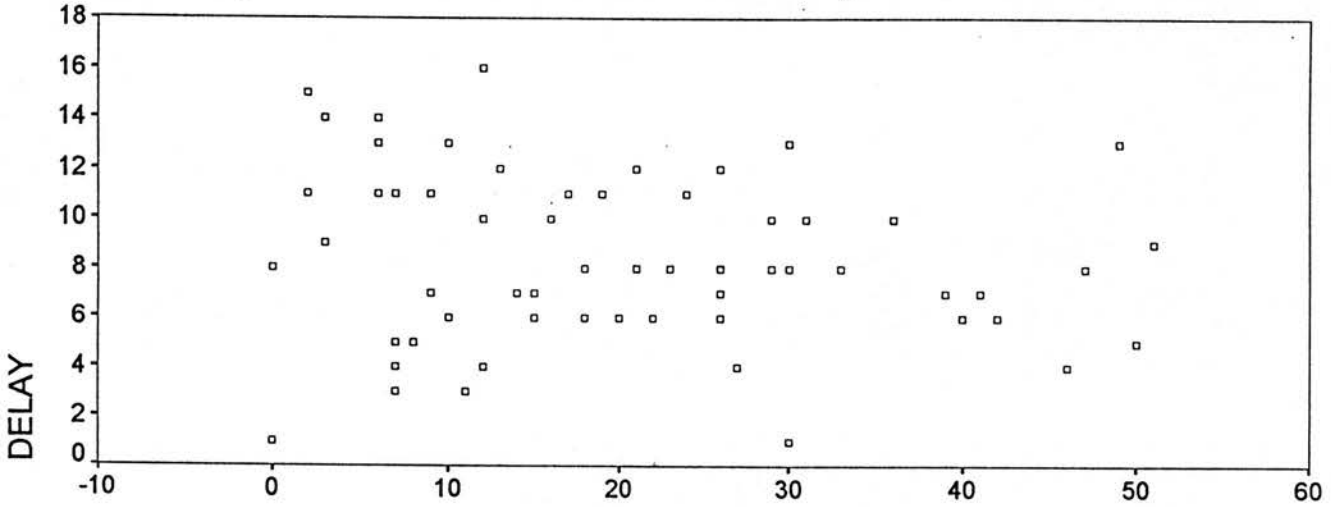


LEARN: Sum of trials 1-5 on the California Verbal Learning Test

SPIEL: Spielberger State Anxiety Inventory

Appendix 1

Scatterplot of anxious mood with delayed recall

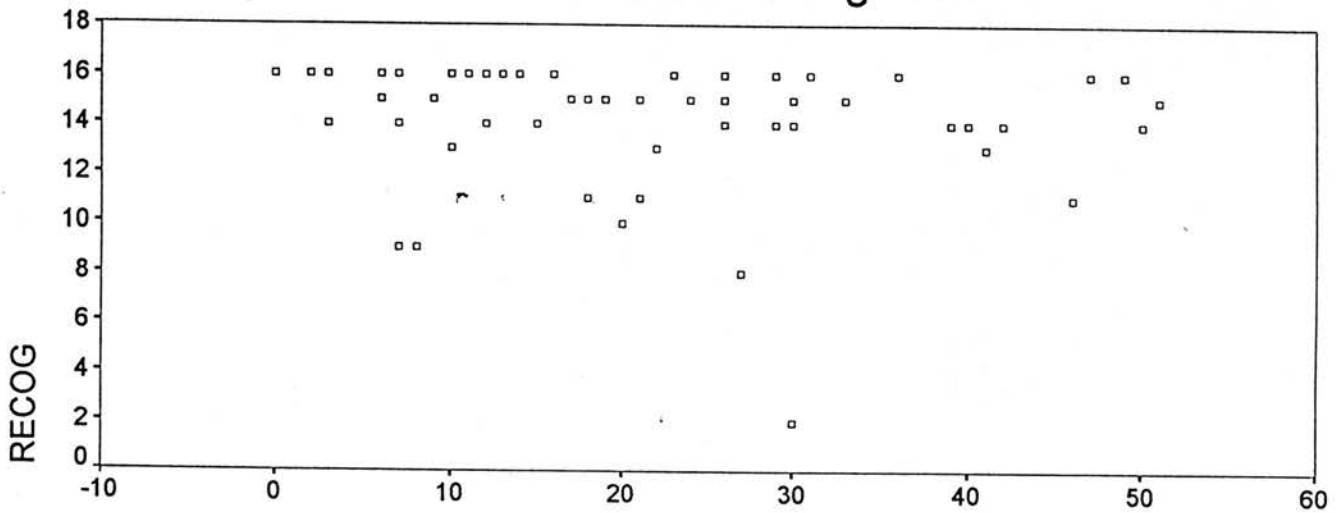


DELAY: Delayed recall on the California Verbal Learning Test

SPIEL: Spielberger State Anxiety Inventory

Appendix 1

Scatterplot of anxious mood with recognition

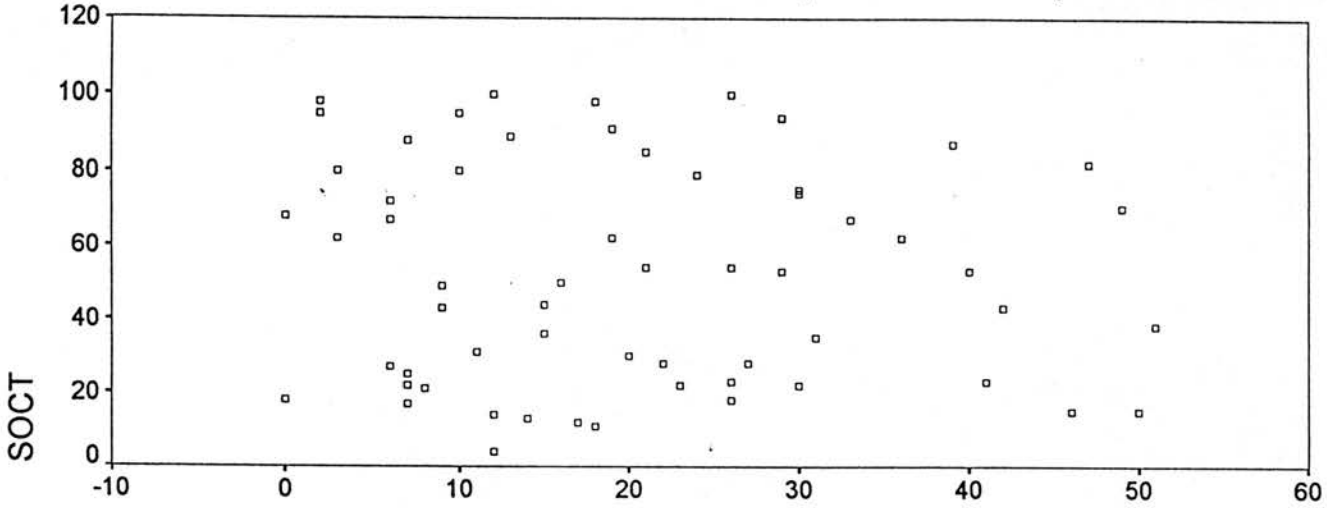


RECOG: Recognition trial of California Verbal Learning Test

SPIEL: Spielberger State Anxiety Inventory

Appendix 1

Scatterplot of anxious mood with Speed of Comprehension

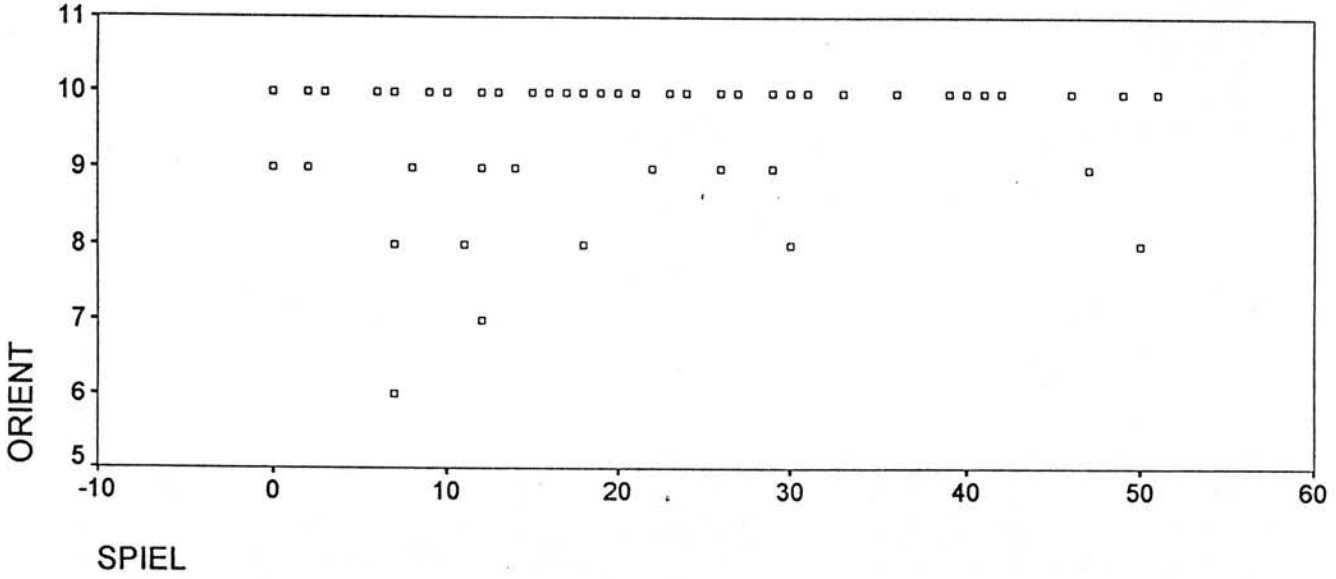


SOCT: Speed of Comprehension Test

SPIEL: Spielberger State Anxiety Inventory

Appendix 1

Scatterplot of anxious mood with orientation

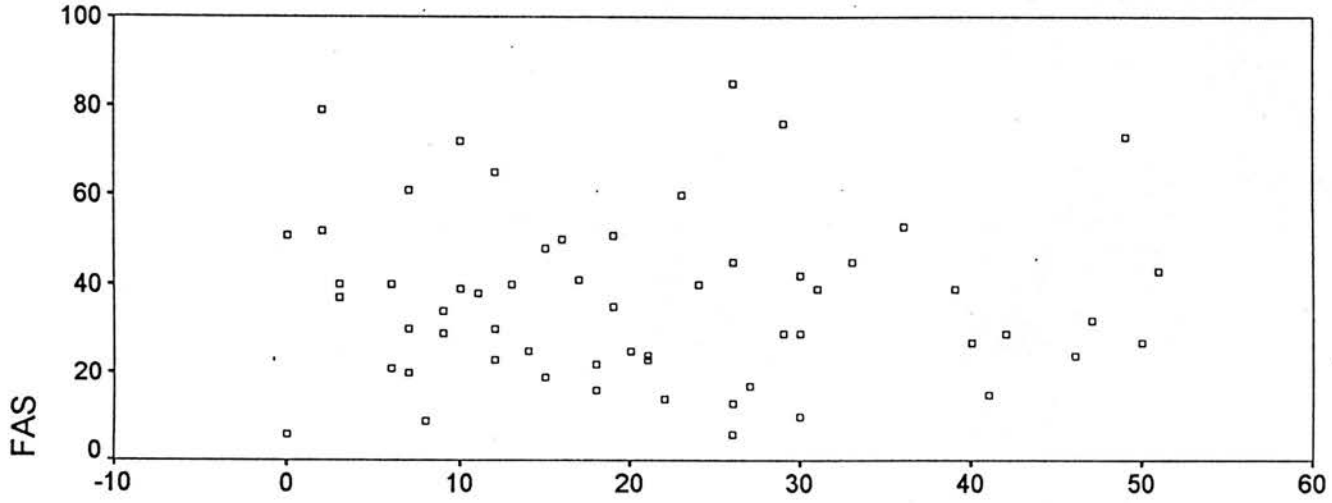


ORIENT: Orientation subscale of Rivermead Behavioural Memory Scale

SPIEL: Spielberger State Anxiety Inventory

Appendix 1

Scatterplot of anxious mood with verbal fluency

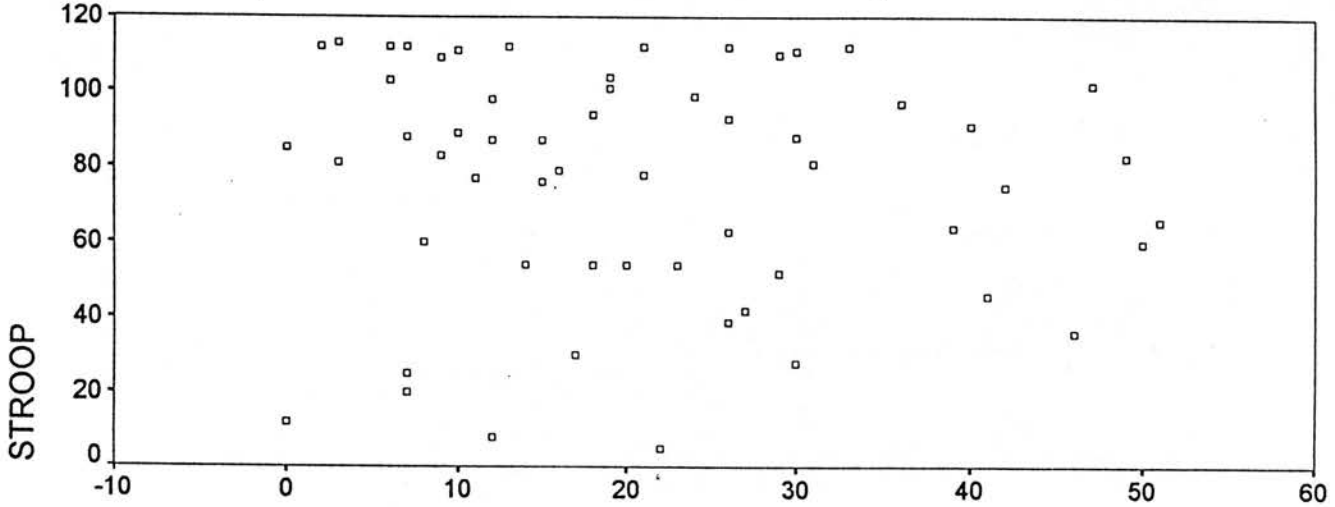


FAS: Controlled Word Association Test

SPIEL: Spielberger State Anxiety Inventory

Appendix 1

Scatterplot of anxious mood with Stroop test

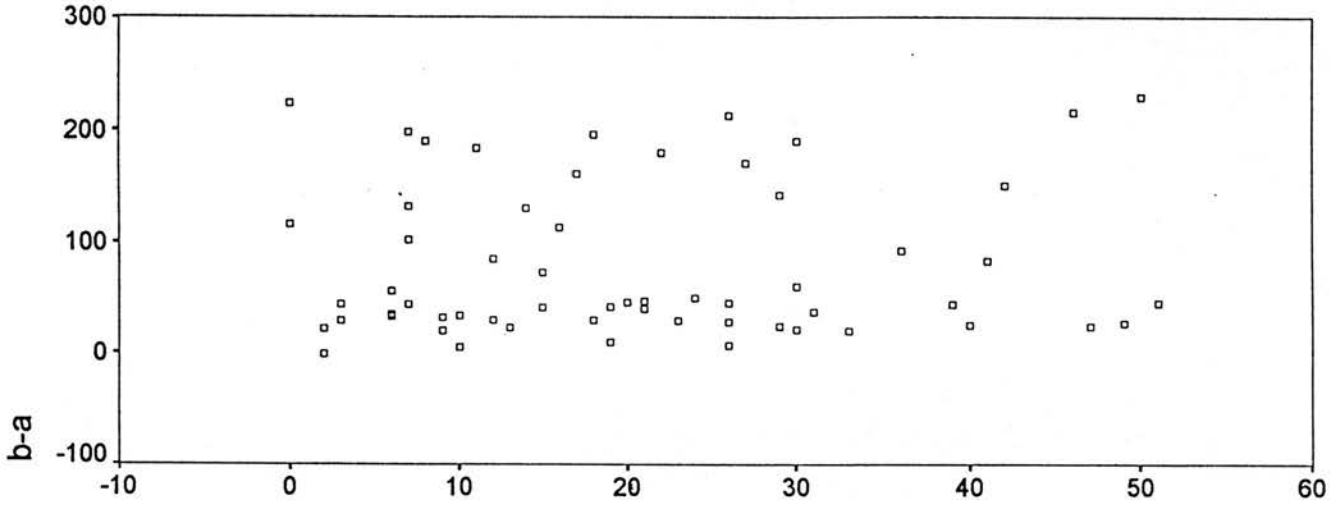


STROOP: STROOP test

SPIEL: Spielberger State Anxiety Inventory

Appendix 1

Scatterplot of anxious mood with TrailsB-A

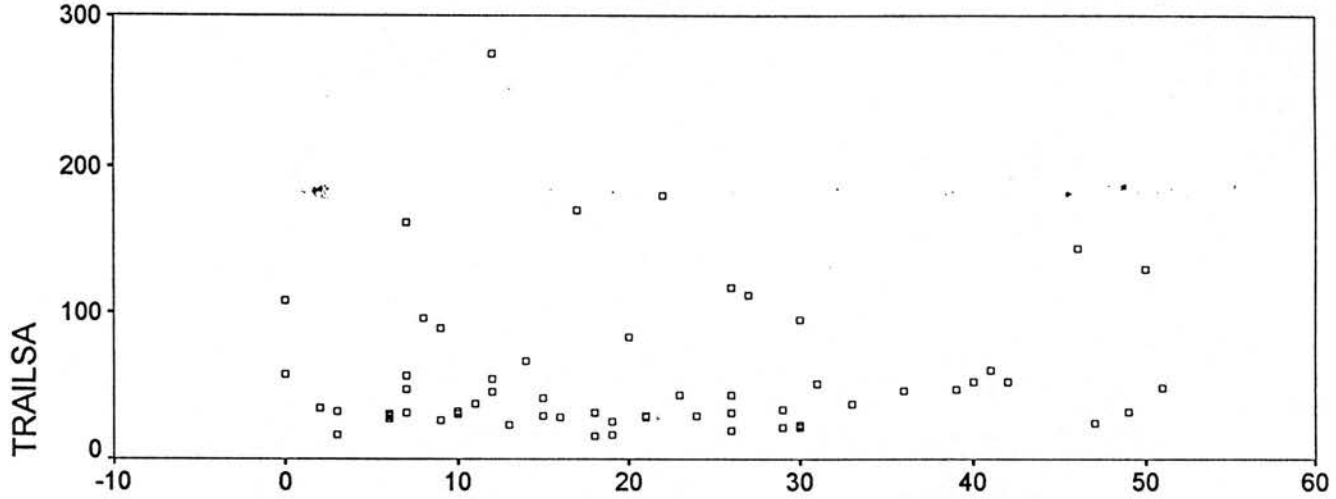


b-a: Time taken to complete TrailsB-A

SPIEL: Spielberger State Anxiety Inventory

Appendix 1

Scatterplot of anxious mood and TrailsA



TRAILSA: Time taken on TrailsA

SPIEL: Spielberger State Anxiety Inventory

APPENDIX 2

Factor analysis of schizophrenic symptoms including anxiety and depression

	Factor 1	Factor 2	Factor 3
Percentage explained of total variance	48.9%	18.9%	13.5%
Anxiety	0.96	0.04	-0.21
Depression	0.86	0.02	-0.10
Delusions	0.72	0.07	0.28
Hallucinations	0.72	-0.05	0.14
Poverty of speech	-0.00	0.96	-0.30
Psychomotor poverty	0.10	0.84	0.16
Flattened Affect	0.00	0.83	0.33
Incoherence of speech	0.03	0.06	0.93

Correlation matrix of extracted factors

	Factor 1	Factor 2	Factor 3
Factor 1	1.00	0.37	0.18
Factor 2	0.37	1.00	0.18
Factor 3	0.18	0.18	1.00

APPENDIX 3

Between-group differences on number of errors made on the Controlled Word Association Test

1. Using a t-test for independent samples, $p = 0.07$

2. Using ANOVA, controlling for age, education and Depcat, significance of $F = 0.22$