FACE PROCESSING IN SCHIZOPHRENIA: AN INVESTIGATION OF CONFIGURAL PROCESSING AND THE RELATIONSHIP WITH FACIAL EMOTION PROCESSING AND NEUROCOGNITION

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Abstract

Cognitive impairment is a key characteristic of schizophrenia and is a clear predictor of functional outcome. This thesis explores the relationship between cognitive ability relating to social and non-social processing. Schizophrenia patients demonstrate an impaired ability to recognise, label and discriminate emotional expression within the face. The underlying mechanisms behind this social cognitive impairment are not yet fully understood. This thesis explores the notion that a basic perceptual impairment in processing facial information adversely impacts on the perception of more complex information derived from faces, such as emotional expression. Face perception relies on processing the featural characteristics of a face as well as the relationship between these features. Information pertaining to the spatial distances between features is referred to as configural information.

A group of schizophrenia patients and healthy control participants completed a battery of tasks that assessed basic neurocognition, facial emotion processing and configural face processing. A model of face processing was proposed and used to systematically pinpoint specific deficits that may contribute to impaired face processing in schizophrenia. The results indicated that schizophrenia patients show impairments on three broad constructs; basic neurocognition, facial emotion processing, and most pertinently, deficits in configural processing. It was revealed that although neurocognitive and face processing both explained a significant proportion of the variance in facial emotion processing, the effect of neurocognition was indirect and mediated by face processing.

To investigate the diagnostic specificity of these findings, a group of bipolar disorder patients was also tested on the task battery. The results indicated that bipolar disorder patients also show social and non-social cognitive impairments, however, not as severe as that demonstrated by the schizophrenia patients. Furthermore, the effect of neurocognitive performance on facial emotion processing appeared more direct for bipolar disorder patients compared to schizophrenia patients. Although deficits in face processing were observable in bipolar, they were not specific to configural processing. Thus, deficits in emotion processing were more associated to neurocognitive ability in bipolar disorder patients, and more associated to configural face processing in schizophrenia patients. The configural processing deficits in schizophrenia are discussed as a lower-order perception problem. In conclusion, the results of this thesis are discussed in terms of their implication for treatment.
Declaration

This is to certify that:

a) This thesis comprises only my original work toward the PhD unless otherwise indicated

b) Due acknowledgment has been made in the text to all other material used

c) The thesis is less than 100,000 words in length, exclusive of tables, figures, bibliography and appendices

___________________________
Nicole R. Joshua
September, 2009
Acknowledgements

I would like to acknowledge a number of individuals who have helped me complete this research. Some have assisted from the very beginning and others have been influential along the way; many will be well into the future.

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National

International
Foreword

I have been fascinated by the human brain since my first psychology class. The more I learnt about cortical functioning the more I realised how such a complex system is vulnerable to fault. Aberrant cognitive processing can lead to poor memory, planning, and attention for example. To me however, the social implications of cognitive error are just as, if not more debilitating to an individual. During many clinical interviews with schizophrenia patients this became particularly apparent. During interviews I asked questions such as "do you have any regrets in life?" and "what are your hopes for the future?". A recurring theme I observed was the need for closer social contacts and the desire to make more friends. This led me to an interest in social cognition in schizophrenia and a desire to understand not only why social skills are problematic for patients but also how they can be improved. This body of work is a collection of studies investigating social cognition in schizophrenia.
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<tr>
<td>SCID</td>
<td>Structured Clinical Interview for DSM-IV</td>
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<td>PANSS</td>
<td>Positive and Negative Syndrome Scale</td>
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<td>BPRS</td>
<td>Brief Psychiatric Rating Scale</td>
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<td>ECT</td>
<td>Electroconvulsive Therapy</td>
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<td>NART</td>
<td>National Adult Reading Test</td>
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<td>BDI</td>
<td>Beck Depression Inventory</td>
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<td>BAI</td>
<td>Beck Anxiety Inventory</td>
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<td>GAF</td>
<td>Global Assessment of Functioning</td>
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<td>STM</td>
<td>Short-term memory</td>
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<td>LTM</td>
<td>Long-term memory</td>
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<td>CPT</td>
<td>Continuous Performance Test</td>
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<td>WCST</td>
<td>Wisconsin Card Sorting Test</td>
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<td>IQ</td>
<td>Intelligence Quotient</td>
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<td>RBANS</td>
<td>Repeatable Battery for the Assessment of Neuropsychological Status</td>
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<tr>
<td>M</td>
<td>Mean</td>
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<td>SD</td>
<td>Standard Deviation</td>
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<td>ANOVA</td>
<td>Analysis of Variance</td>
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<td>ANCOVA</td>
<td>Analysis of Covariance</td>
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<td>BADS</td>
<td>Behavioural Assessment of the Dysexecutive Syndrome</td>
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<td>NIMH</td>
<td>National Institute of Mental Health</td>
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<td>MATRICS</td>
<td>Measurement and Treatment Research to Improve Cognition in Schizophrenia</td>
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<td>PoFA</td>
<td>Pictures of Facial Affect</td>
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<td>FACS</td>
<td>Facial Affect Coding System</td>
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<td>AU</td>
<td>Action Unit</td>
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<td>FEIT</td>
<td>Facial Emotion Identification Test</td>
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<td>FEDT</td>
<td>Facial Emotion Discrimination Test</td>
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<td>CBT</td>
<td>Cognitive Behavioural Therapy</td>
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<td>TAR</td>
<td>Training of Affect Recognition</td>
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<td>FFA</td>
<td>Fusiform Face Area</td>
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<td>OFA</td>
<td>Occipital Face Area</td>
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<td>ERP</td>
<td>Event Related Potential</td>
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<td>fMRI</td>
<td>Functional Magnetic Resonance Imaging</td>
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<td>PET</td>
<td>Positron Emission Tomography</td>
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<td>FIE</td>
<td>Face Inversion Effect</td>
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<td>MRS</td>
<td>Mania Rating Scale</td>
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<td>NMDA</td>
<td>N-methyl-D-asparate</td>
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<td>IM</td>
<td>Immediate Memory</td>
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<td>DM</td>
<td>Delayed Memory</td>
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<td>Attention</td>
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<td>Language</td>
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<td>VSC</td>
<td>Visuospatial/Constructional</td>
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<td>RBTOT</td>
<td>RBANS Total Score</td>
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<td>HAP</td>
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<td>Scrambled Faces Task</td>
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<td>Featural Task</td>
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<td>MOON</td>
<td>Mooney Faces Task</td>
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<td>CPA</td>
<td>Complete-over-part Probe Advantage</td>
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Chapter 1  Introduction

The general aim for this body of work was to examine the problems in social cognition experienced by schizophrenia patients, and to provide insight into the specific abnormal mechanisms and visual perceptual styles which may contribute to such problems. By investigating the relationship between social and non-social cognition, clinicians and researchers will be better equipped to develop appropriate remediation tools to alleviate some of the symptoms and social difficulties experienced by schizophrenia patients.

This introductory chapter will begin with a brief explanation of the diagnosis, symptomatology, epidemiology, aetiology and treatment of schizophrenia; thereafter will follow a discussion of the neurocognitive and social cognitive characteristics relating to the disorder. The specific aims, hypotheses and research questions will then be highlighted followed by the significance of this area of research. Lastly, this chapter will include a summary of the organisation of the thesis.

1.1  Introduction to Schizophrenia

In 1893, Emil Kraeplin (1919) first described a mental disorder he called dementia praecox. This was later renamed by Eugen Bleuler in 1911, and is the psychiatric condition we know today as schizophrenia (Bleuler, 1911). Schizophrenia is a chronic, heterogeneous, psychiatric condition. Characterised by distortions in reality testing and expression, its debilitating symptoms can impact on cognition, emotion and conduct. Today the primary diagnostic tools for schizophrenia are the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR, American Psychiatric Association, 2000) and the World Health Organization's International Statistical Classification of Diseases and Related Health Problems (ICD-10, World Health Organization, 1993). Although these tools have come under criticism due of the strict operational criteria used to classify mental illness, they are nonetheless of standard use by clinicians and researchers.

The DSM-IV-TR indicates a diagnosis of schizophrenia requires symptoms to be present for at least one month (unless otherwise treated) during a period of at least six months of disturbed functioning. Diagnosis is reliant upon self-reports from patients, behavioural observations by family, friends and co-workers, as well as examinations by psychiatrists, case managers or other
clinicians. The symptom classification used in the DSM-IV-TR surrounds the distinction between positive and negative symptomatology. Positive symptoms involve the manifestation, excess or distortion of normal function, including symptoms not normally experienced. Such symptoms include impaired perception (hallucinations), reality testing (delusions), disorganized thought and speech, and disorganized or catatonic behaviour. In contrast, negative symptoms involve a decrease or absence of normal abilities, including flat or blunted emotional expression, reduction of speech (i.e. alogia) or motivation (i.e. avolition), and the limited ability to experience pleasure (i.e. anhedonia). The assessment of these symptoms is commonly made via the Positive and Negative Syndrome Scale (PANSS, Kay et al., 1987). This tool provides a standardized measure for the severity (based on a 7-point scale) of positive, negative and global psychopathology (i.e. aggression, disorientation, preoccupation).

Considering the heterogeneous presentation of schizophrenia, several attempts have been made to differentiate subtypes of the disorder. Corresponding to the symptom differentiation, some consider subtypes of schizophrenia as either positive or negative (Andreasen, 1983, 1984; Kay et al., 1987); others favour the terms deficit (prominently negative symptoms) vs. non-deficit (prominently positive symptoms) (Carpenter et al., 1988; Kirkpatrick et al., 1989) or paranoid vs. non-paranoid (Magaro, 1981; Magaro et al., 1981). The DSM-IV considers five subtypes, i.e. paranoid, disorganised (ICD termed hebephrenic), catatonic, undifferentiated and residual (APA, 2000; WHO, 1993).

The lifetime prevalence of schizophrenia is reported to be around 0.4% of the population (Bhugra, 2005; Saha et al., 2005). Generally, the prevalence of schizophrenia in males and females is equal (Goldner et al., 2002). Symptoms typically begin to present during young adulthood; however the age at illness onset is earlier for males (18–25 years) than females (25–32 years) who also show a second onset peak midlife (APA, 2000). Symptoms may present insidiously or acutely. There are no recognized definitive tests for schizophrenia, as there is no clear known cause for the disorder. Research has suggested that genetic, environmental, neurobiological, psychological and social processes are all potentially important factors contributing to the development of schizophrenia. At present there is no recognised cure, and full remission is, unfortunately, not common for schizophrenia patients.

The most effective and widespread treatment for schizophrenia is pharmacotherapy utilizing antipsychotic medication that acts on the dopaminergic system. Such medication has improved
considerably over the past 20 years, and can successfully control hallucinations and delusional thinking, with only minimal side-effects in a large proportion of patients. In the last ten years, patients have also come to often rely on psychotherapy, vocational and social rehabilitation in conjunction with their pharmacological treatment. These adjunct treatments have resulted in better day-to-day functioning and quality of life. Some patients are resistant to antipsychotic medication, thus such alternative forms of treatment are imperative.

### 1.2 The Costs of Schizophrenia

Schizophrenia is a disorder leading to extremely severe consequences both on an individual and community level. A report by SANE Australia, indicated schizophrenia as a disorder costs Australia $1.85 billion per annum (SANE, 2005). Carr et al. (2003) indicated the cost to the Australian Federal government at $1.45 billion per annum, and societal costs $2.25 billion per annum. It is clear that functional and interpersonal difficulties in schizophrenia substantially contribute to mental health care costs. Ustun (1999) collected the opinions of health professionals, policy makers, individuals with disabilities and carers from 14 different countries and revealed ‘active psychosis’ was rated as the third most debilitating condition behind quadriplegia and dementia. The findings indicated active psychosis was more debilitating than blindness, depression, alcoholism and many other severe conditions.

From an individual’s perspective, symptoms of schizophrenia have the potential to be very debilitating, and patients often suffer from significant impairment in personal, occupational and social circumstances. Reality distortions leave many unable to work leading to poverty, malnourishment and homelessness. Other affective symptoms can leave individuals socially isolated with little social support. Many patients self-medicate with illicit substances which ultimately often exacerbate their symptoms. Sadly, these factors, combined with high suicide rates, i.e. 12 times that of the general population (Barbato, 1997), contribute to the reduced life expectancy of schizophrenia patients (Brown et al., 2000).

### 1.3 Cognition in Schizophrenia

Early discussions of schizophrenia focused heavily on the positive symptoms of the disorder, in the 1980’s descriptions developed to also emphasise the negative symptoms. During the 1990’s the focus shifted beyond the classical positive and negative symptoms and towards the cognitive
deficits shown by schizophrenia patients. While pharmacological treatment can effectively control psychotic symptoms, the neurocognitive deficits such as memory, attention and problem solving, often remain problematic for patients (Blyler & Gold, 2000; Purdon et al., 2000). The specific neurocognitive deficits shown by schizophrenia patients will be addressed in greater detail in Chapter Three. Investigations into neurocognition in schizophrenia are extremely important and can have a major role in understanding the illness course. While the outcome for schizophrenia patients can be difficult to predict based on symptomatology, cognitive performance can be a strong predictor of functional outcome (Green, 1996; Green et al., 2000). For example, neurocognitive performance is a better predictor of employment status for schizophrenia patients than clinical symptoms are (Kaneda et al., 2009).

The research into cognition in schizophrenia has recently extended beyond the classical, non-social aspects of cognition, with a more recent shift to the social cognitive deficits, and the associated functional relevance of these deficits (Couture et al., 2006). Neurocognition (i.e. memory, language, attention, executive functioning) and social cognition (i.e. social perception, attributional style, theory of mind, emotion processing) are independent but related constructs (Penn et al., 1997). They both relate to functional outcome with some overlap; however, they also, in part, contribute independently (Brekke et al., 2007). Interestingly, social cognitive assessment measures appear to distinguish schizophrenia patients from non-patients better than non-social cognitive assessment measures (Penn et al., 1997).

Considered broadly, social cognition sets the foundations for peer, romantic and family relationships. Social cognition embraces several different constructs ranging from skills in interpersonal communication, community functioning, social problems solving, stable employment, and even less directly independent living abilities such as self-care, grooming, financial responsibility. Schizophrenia patients show problems in many of these areas. Social cognitive ability is related to rate of relapse (Robinson et al., 1999), illness course, and unemployment (Couture et al., 2006). Poor social cognition is a key characteristic of schizophrenia and is observable in patients even before illness onset, as well as in first-degree relatives of schizophrenia patients.

Clearly, there are many aspects to social cognition; however, the current body of work will focus on emotion processing. While emotion processing can be assessed in different modalities, including prosody and body language, this work will specifically investigate the visual processing
of emotional content from the human face. Facial emotion processing (also referred to as emotion recognition and affect perception) in a broad sense relates to how we interpret other peoples’ feelings and emotions through their facial expressions. This is a complex task as facial expression can change very quickly, may vary greatly between individuals and may be reflected by subtle micro-expressions. Nonetheless, our ability to perceive and understand the facial expressions of others is critical to successful social interaction and a deficit to do so can result in a significant social handicap. For example, imagine misinterpreting a sad face as threatening. If we are unable to effectively read the emotional cues demonstrated by family, friends and peers, problems understanding social situations are palpable.

Previous research has indicated that schizophrenia patients do show deficits in facial emotion processing, whereby patients do not process universally recognisable facial emotions as accurately as controls (Edwards et al., 2002) (this literature will be reviewed more thoroughly in chapter 4. These deficits are relatively unaffected by traditional antipsychotics (Gaebel & Wolwer, 1992), however, may show some improvement with the newer atypical antipsychotics (Kee et al., 1998b). Emotion processing deficits are related to chronicity of illness (Penn et al., 2000) and poor social functioning (Mueser et al., 1996), and are correlated to other social cognition skills such as interpersonal skills (Poole et al., 2000) and social problem solving (Vaskinn et al., 2008). Interestingly, some suggest that the ability to process facial emotional information may mediate the relationship between neurocognition and functional outcome for schizophrenia patients (Addington et al., 2006), and may contribute to the development of psychosis (Frith, 1992).

A substantial literature has investigated facial emotion processing in schizophrenia; however, study design has varied considerably, resulting in a number of conflicting findings. Some argue for a specific deficit for processing negatively valanced emotions only (Bediou et al., 2005), while others argue a generalised deficit common to all emotional expressions (Johnston et al., 2001). The current body of work favours the latter. Consequently, this work will investigate the underlying processing styles common to face processing (this will be described in chapter 5). Aberrant perception of facial information, specifically configural information, will unquestionably lead to poorer recognition of facial emotional expression. Configural information refers to the specific spatial relations between facial features, e.g. the distance between the eyes. Therefore, this work will investigate face processing, specifically configural processing, in schizophrenia. Upon design of this thesis, few studies had investigated the
processing styles common to face processing in schizophrenia, however, now several studies substantiate this line of thinking (Baudouin et al., 2008; Chambon et al., 2006; Chen et al., 2008; Shin et al., 2008).

1.4 Overall Aims & Hypotheses

This thesis reports research undertaken to assess the relationship between non-social and social cognitive impairments in schizophrenia. Specifically, the current body of work aimed to examine the underlying processes required for accurate perception of facial information, the process predicted to be impaired was configural processing. Furthermore, an additional aim was to assess whether the cognitive impairments examined in this thesis were specific to schizophrenia; or problematic for other psychosis patients, thus this research examined cognitive performance in a group of patients with bipolar disorder. Overall, it was hypothesised that higher-order (non-social) cognitive and lower-order configural processing problems contribute to the social cognitive impairments in facial emotion processing demonstrated by schizophrenia patients. Specific aims and hypotheses are presented in each of the subsequent empirical chapters.

1.5 Study Questions

After a review of the literature, the following questions became apparent (it was these questions that drove the empirical investigations presented in this thesis):

- Could the facial emotion processing deficit in schizophrenia be due to an underlying problem processing facial information regardless of emotional content?
- Are the facial emotion processing deficits shown by schizophrenia patients a consequence of aberrant configural processing strategies?
- Does face processing ability mediate the relationship between neurocognitive performance and emotion processing in schizophrenia?
- Are the problems specific to schizophrenia?
1.6 Significance of this Research

Testing and integrating existing models of face perception will provide the ability to pinpoint key deficits in face perception that may contribute to impaired facial emotion processing in schizophrenia. A better understanding of social cognitive ability in schizophrenia may aid in diagnosis, subtyping, and treatment options for the disorder. As a result of the recent focus on social cognitive investigations in schizophrenia, current therapeutic interventions are changing accordingly. Psychotherapy treatment options have begun to focus on the remediation of emotion processing in psychosis, with some promising outcomes (Combs et al., 2006; Frommann et al., 2003; Russell et al., 2006; Wolwer et al., 2005). Such techniques are aimed at ameliorating many of the problems for schizophrenia patients with a focus on long-term improvement in quality of life. Specifically, reducing frequency and length of hospitalisation and long periods on anti-psychotic medications, improving social functioning and consequently, improving interpersonal communication and community integration. For these techniques to be successful a sound understanding of the cognitive mechanisms involved in emotion processing is crucial (Morris et al., 2009); this research will contribute to this understanding.

1.7 Outline and Organisation of Thesis

This thesis is comprised of eight chapters. The first chapter has provided a brief introduction to the symptoms, diagnosis and consequences of schizophrenia, as well as providing an overview of the aims, hypotheses and significance of the current body of work.

Chapter two will provide details on the participant characteristics and testing conditions common to all the behavioural cognitive work described in the current thesis. This chapter will highlight the similarities and differences between the healthy control participants and schizophrenia patients who participated in this research, as well as detailing the recruitment strategies, demographics, symptomatology and medication information. Further, chapter two will provide the reader with an understanding of the conditions and general procedures undertaken during each testing session.

Chapter three will discuss in greater detail the neurocognitive impairment demonstrated by schizophrenia patients. The neurocognitive performance of the current sample will be presented
and compared to other schizophrenia samples. The strengths and weaknesses of the schizophrenia patients will be discussed in respect to healthy control performance.

Chapter four will go on to discuss the social cognition impairment in schizophrenia, specifically relating to facial emotion processing. The current samples will be assessed on different aspects of facial emotion processing and the results will be discussed.

Chapter five is the largest chapter of this thesis, and will discuss the processing styles underlying human face perception. These processing styles will be systematically tested in the healthy control and schizophrenia samples via a range of different face perception tasks. A model of face perception will be presented and discussed in relation to schizophrenia performance.

Chapter six is the integrative chapter of this thesis, and will explore the associations between neurocognition, facial emotion processing and face processing. The direct and indirect influences of neurocognitive ability on facial emotion perception will be assessed using multiple regression techniques.

Chapter seven will investigate the diagnostic specificity of the non-social and social cognitive impairment shown by schizophrenia patients. Comparisons will be drawn between schizophrenia and bipolar disorder patients; and discriminate functional analysis techniques will be used to explore how accurately neurocognitive, emotion processing and face processing measures are able to discriminate between the two patient groups.

Chapter eight will summarise the results and discuss the limitations of the study. Thereafter, the implications of these results will be discussed in terms of how the findings may contribute to future remediation of emotion processing.
Chapter 2  Methods

This body of work was based primarily on the behavioural data from a battery of tasks administered to two participant groups. The research protocol was approved by the Melbourne University Human Ethics Committee. Each of the tasks to be described in the experimental chapters 3-5, was administered to the same two groups of participants, during the one experimental session, under the same testing conditions. Therefore, the participant characteristics and testing conditions will be summarised in this chapter to avoid repetition.

2.1 Participant Information

2.1.1 Recruitment, Diagnosis & Inclusion Criteria

Group 1 involved 29 individuals with schizophrenia (aged 20 - 63 years). These participants were recruited via community support groups and community care units. All were out-patients and tested during a period of clinical stability as determined by the primary investigator. Diagnosis was confirmed using the Structured Clinical Interview for DSM-IV (SCID, First et al., 1996). Current symptomatology was acquired using the Positive and Negative Syndrome Scale (PANSS, Kay et al., 1987). Schizophrenia patients experienced no other Axis 1 comorbidities. Five of the schizophrenia patients had received electroconvulsive therapy (ECT) in the past, however none within the year prior to testing. Eighteen of the schizophrenia patients had never used illicit drugs, three had used illicit drugs experimentally, six had a history of recreational drug use and two had used illicit drugs within the three months prior to testing, however, not within 24 hours of testing.

Group 2 involved 29 healthy control participants (aged 27 - 64 years) who were recruited via newspaper advertisements and posters at community centres (Appendix 1). They were not students and were recruited from similar geographical locations as group one; this was an attempt to represent a demographically similar control group. Control participants were screened for previous history of psychiatric disorder, substance abuse disorder, and familial history of psychosis using a demographic questionnaire modelled on the SCID. They were screened for current symptoms using the Brief Psychiatric Rating Scale (BPRS, Overall & Gorham, 1980). Participants were excluded if they demonstrated any indication of psychotic...
presentation or Axis 1 diagnosis. Nineteen of the control participants had never used illicit drugs, six had used illicit drugs experimentally, three had a history of recreational drug use and one had used illicit drugs within the three months prior to testing, however, not within 24 hours of testing. Thus, illicit drug use was similar across the two groups. Control participants were excluded if they had a first-degree relative diagnosed with either schizophrenia or bipolar disorder.

All participants met the following inclusion criteria: a) No history of neurological disorder or head trauma as determined by self report, b) No diagnosable current drug or alcohol abuse disorder, c) English spoken as first language, d) Aged between 18-65 years and e) Estimated intelligence quotient (IQ) >85 from the National Adult Reading Test (NART, Nelson & Willison, 1991) so not to include individuals with intellectual disability.

2.1.2 Demographic Characteristics

The demographic characteristics of the two participant groups are summarised in Table 1. Note all numbers in table refer to mean (standard deviation) unless otherwise stated. There was no significant difference in age between schizophrenia patients and controls. Males were significantly over represented among the schizophrenia participants than control participants. The handedness distribution did not differ significantly between the two groups as determined using the Edinburgh Handedness Questionnaire (EHD, Oldfield, 1971).

2.1.3 Estimated Intelligence

The NART was used as an estimate of pre-morbid verbal IQ (Morrison et al., 2000). This measure consisted of 50 irregularly pronounced words (i.e. chord). Participants were required to read the words aloud, and the number of pronunciation errors was converted into an IQ score. Independent samples t-tests indicated schizophrenia patients showed significantly lower IQ predicted by the NART than controls. Considering the group difference in predicted IQ, this variable will be considered as a potential covariate in further task-related analyses described in later chapters.
### Table 1. Participant Demographic Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Controls $n=29$</th>
<th>Schizophrenia $n=29$</th>
<th>Comparisons$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>42.86 (11.33)</td>
<td>39.24 (11.12)</td>
<td>$t(56)=1.23$</td>
</tr>
<tr>
<td>% Male</td>
<td>45</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>% Right-handedness</td>
<td>83</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>NART</td>
<td>113.93 (7.44)</td>
<td>106.28 (10.94)</td>
<td>$t(56)=3.1^{**}$</td>
</tr>
<tr>
<td>Education (years)</td>
<td>17.02 (2.55)</td>
<td>14.53 (2.83)</td>
<td>$t(56)=3.51^{**}$</td>
</tr>
</tbody>
</table>

Note: $^1$Comparisons refer to independent samples t-tests (age, NART, education) and chi-squared tests (gender, handedness). NART: National Adult Reading Test.

* $p<0.05$, ** $p<0.001$

#### 2.1.4 Education

Ten schizophrenia patients had ceased formal education before completing secondary school, five had completed secondary school and 14 had gone on to tertiary education. Seven of the control participants had completed their formal education at a secondary school level and 22 had gone on to tertiary education. As shown in Table 1, overall schizophrenia patients had completed significantly fewer years of education than control participants. Similar to predicted IQ, years of education will also be considered as a potential covariate in further task-related analyses described in later chapters.

#### 2.1.5 Employment

In the schizophrenia group, one patient was employed full-time, five part-time, two were unemployed, one completed home duties, and 20 were receiving disability pensions. In the control group, 13 were employed in paid work full-time, four part-time, four casual, two completed home duties, two were students and four were retired.

#### 2.1.6 Living Situation

Sixteen schizophrenia patients were living in government housing, four were living in the family home and nine were living independently. All 29 healthy controls were living independently.

#### 2.1.7 Mood Assessment

Participants completed the Beck Depression Inventory (BDI, Beck et al., 1996) and the Beck Anxiety Inventory (BAI, Beck & Steer, 1990). These self-assessment questionnaires provided
information on current levels of depression and anxiety. They were quick, 21-item measures each rated on a scale from 0-3, providing a total score between 0-63. Independent samples t-tests on the BDI indicated schizophrenia patients had significantly higher ratings ($M=14.38$, $SD=11.33$) than control participants ($M=2.48$, $SD=3.08$) ($t(32.11)=-5.46$, $p<0.05$). Analysis on the BAI also indicated higher ratings for schizophrenia patients ($M=15.48$, $SD=11.44$) than controls ($M=5.14$, $SD=4.40$) ($t(36.10)=-4.55$, $p<0.05$). These levels of depression and anxiety in schizophrenia are slightly higher than those previously published in Australian samples (Waters et al., 2003). According to the BDI and BAI guidelines, schizophrenia patients on average displayed ‘mild’ depression and anxiety, and controls displayed ‘minimal’ depression and anxiety.

2.1.8 Psychopathological Characteristics

The average age of illness onset and illness duration for the schizophrenia group is indicated below in Table 2. Participants were rated on the PANSS which provided information on current symptomatology. The rating scale involved 30 items each rated from one (absent) to seven (extreme). There were seven items relating to positive symptoms (range 7-49), seven for negative symptoms (range 7-49) and 16 for general psychopathological symptoms (range 16-112), thus providing three factor scores which summed together for an overall total score (range 30-210). Average scores for the current schizophrenia sample are shown in Table 2. These scores indicate similar levels of psychopathology as those reported in other Australian schizophrenia samples (Loughland et al., 2007).

Table 2. Psychopathological Characteristics of Schizophrenia Patients

<table>
<thead>
<tr>
<th>Schizophrenia Patients $n=29$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at illness onset (years)</td>
</tr>
<tr>
<td>Illness duration (years)</td>
</tr>
<tr>
<td>PANSS Positive</td>
</tr>
<tr>
<td>PANSS Negative</td>
</tr>
<tr>
<td>PANSS General</td>
</tr>
<tr>
<td>PANSS Total</td>
</tr>
<tr>
<td>GAF</td>
</tr>
</tbody>
</table>

PANSS: Positive and Negative Syndrome Scale; GAF: Global Assessment of Functioning

Control participants were screened for current psychiatric characteristics using the BPRS. This was a relatively short interview involving questions and observations relating to 24 different constructs (i.e. grandiosity, suspiciousness, hallucinations) each rated from one (not present) to
seven (extremely severe), resulting in a possible range on 24-168. Control participants from the current sample averaged a total score of 28.45 ($SD=2.85$). No participant scored over 34 on the BPRS, and consequently no control participant was excluded based on psychiatric rating.

2.1.9 **Global Assessment of Functioning**

Schizophrenia patients were rated on the Global Assessment of Functioning scale (GAF) which is the Axis V scale of the DSM-IV (APA, 2000). This was used as a measure of overall functioning providing a single possible score between 0-100. As indicated in Table 2, patients from the current sample averaged a score of 53.14 with a range of 27-77. In a large sample of Australian schizophrenia patients, Loughland et al. (2007) derived three levels of functioning based on GAF scores; low ≤ 50, medium 51-60, and high >60. Thus, on average the current sample corresponds to the ‘medium’ level functioning group as described by Loughland et al.

Upon further investigation of the individual scores, overall there was a relatively even split of patients in each level of functioning; 11 low functioning (38%), nine medium (31%), nine high (31%). Table 3 below indicates there was no significant difference in age, gender, years of education, NART, illness onset or length of illness between these three subgroups. The PANSS ratings indicated an expected pattern of results, with the lower functioning subgroup scoring significantly higher than the medium and high subgroups on all PANSS scores. The medium and high subgroups did not differ from one another on these measures.

**Table 3. Demographic Comparisons between Low, Medium and High Functioning Subgroups of Schizophrenia Patients**

<table>
<thead>
<tr>
<th></th>
<th>Low $n=11$</th>
<th>Medium $n=9$</th>
<th>High $n=9$</th>
<th>Comparisons$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>33.36 (8.76)</td>
<td>42.33 (8.97)</td>
<td>43.33 (13.35)</td>
<td>$F(2,26)=2.83$</td>
</tr>
<tr>
<td>% Male</td>
<td>82</td>
<td>56</td>
<td>78</td>
<td>$\chi^2(2,N=29)=1.83$</td>
</tr>
<tr>
<td>Education (years)</td>
<td>14.82 (2.55)</td>
<td>14.44 (2.92)</td>
<td>14.28 (3.35)</td>
<td>$F(2,26)=0.09$</td>
</tr>
<tr>
<td>NART</td>
<td>106.00 (9.42)</td>
<td>108.22 (12.27)</td>
<td>104.67 (12.24)</td>
<td>$F(2,26)=0.23$</td>
</tr>
<tr>
<td>Age at illness onset (years)</td>
<td>22.30 (6.58)</td>
<td>23.78 (8.70)</td>
<td>21.78 (4.79)</td>
<td>$F(2,26)=0.21$</td>
</tr>
<tr>
<td>Illness duration (years)</td>
<td>11.00 (7.01)</td>
<td>18.56 (8.65)</td>
<td>21.78 (12.88)</td>
<td>$F(2,26)=3.10$</td>
</tr>
<tr>
<td>PANSS Positive</td>
<td>16.18 (4.64)</td>
<td>12.11 (2.57)</td>
<td>9.56 (3.43)</td>
<td>$F(2,26)=8.05^{**}$</td>
</tr>
<tr>
<td>PANSS Negative</td>
<td>16.73 (7.35)</td>
<td>11.67 (4.77)</td>
<td>10.44 (3.43)</td>
<td>$F(2,26)=3.60^*$</td>
</tr>
<tr>
<td>PANSS General</td>
<td>29.82 (7.48)</td>
<td>23.89 (4.76)</td>
<td>20.67 (2.65)</td>
<td>$F(2,26)=7.10^{**}$</td>
</tr>
<tr>
<td>PANSS Total</td>
<td>32.76 (13.28)</td>
<td>46.56 (9.67)</td>
<td>40.67 (5.48)</td>
<td>$F(2,26)=12.52^{**}$</td>
</tr>
</tbody>
</table>

Note: $^1$Comparisons refer to one-way analysis of variance and chi-squared tests (gender). NART: National Adult Reading Test, PANSS: Positive and Negative Syndrome Scale

$^*$ $p<0.05$, $^{**} p<0.01$
2.1.10 Medication

The schizophrenia sample were prescribed with a range of different medications and dosages, therefore it was not possible to determine the role of medication on performance or control for these possible effects. Ethically it was not appropriate to take patients off their medication for cognitive testing purposes. Furthermore, patients taken off medication may have experienced withdrawal effects that could have impacted on task performance. Overall 21 patients were taking antipsychotic medication alone (two typical, 17 atypical, two combination), five were taking antipsychotics (four atypical, one combination) and an antidepressant, one was taking an antipsychotic (atypical) and a mood stabiliser, one was taking a combination of an antipsychotic (atypical), an antidepressant and a mood stabiliser, and one was medication free. For those schizophrenia patients taking antipsychotic medication (N=28), the average chlorpromazine equivalent (CPZe) was 500.13mg CPZe/day (SD=280.24).

Pearson’s Product moment correlation coefficients were examined to investigate the relationship between age and the psychopathological characteristics of the schizophrenia participants. Age was not significantly correlated with medication dosage, GAF or PANSS positive factor score. There were however, significant negative correlations between age and PANSS general factor score (r=-.40) and total factor score (r=.41) as well as a trend for PANSS negative factor score (r=-.36, p=0.06). It was apparent that the younger patients demonstrated significantly less severe psychopathological characteristics than the older patients.

2.2 Procedure, Testing Conditions and Apparatus

Participants who had expressed interest in the advertised project were initially contacted via telephone and briefly explained the study details. Once they agreed to attend a test session they were mailed the Plain Language Statement (Appendix 2) detailing the project at least two days prior to their testing session, during which time they were able to call and withdraw from the session or ask any questions. On the day of their session they were met at the reception of the National Neuroscience Facility in Carlton, Melbourne. Participants were then escorted to the testing room, which was a small, quiet room with only the materials needed for the session and no other distractions (no windows, no wall coverings). After a complete description of the study was given, written informed consent was obtained from all participants. They were informed they were able to withdraw this consent at any time. Participants were permitted breaks at any
time during the session. Once consent had been obtained, each participant was assigned a code which was used to label all subsequent data and paperwork. This was done to ensure anonymity of participant identity was maintained. All data and identifiable information was kept in a locked cabinet, accessible only to those directly associated with the project.

All participants then underwent the interview phase of the testing session, which took up to one hour. This included the SCID, PANSS and GAF for the schizophrenia patients and the BPRS for the control participants. All participants then completed the NART, BDI and BAI. All participants NART scores were above that required for inclusion in the project (i.e. >85).

After the interview phase of the session, participants completed the behavioural task battery involving a number of neurocognitive and social cognitive tasks which will be discussed in further detail in the following chapters. This behavioural testing part of the session took approximately 2½ hours. Several tasks required written or oral answers, whereas others were completed on a laptop computer presented on a standard 15.4inch computer screen. Participants were seated approximately 60cm in front of the screen. Participants used a hand controller to respond during these tasks via either a 2-button or 4-button press. Tasks were completed in a novel randomised order for each participant.

### 2.3 Task Battery

The task battery was compiled to assess the relationship between neurocognition and social cognition and to further investigate the mechanisms behind face processing. The task battery included 14 different tasks, which are discussed in greater detail in the following chapters. Some of the tasks were existing standardised tests which had been used previously in schizophrenia research, and others had been modified or were completely novel in their design. When using standardised tests, strict care was taken to follow testing and scoring guidelines. When the tasks were novel, each underwent pilot testing to confirm reliability and validity.

### 2.4 Statistical Analysis

All statistical analysis was completed using SPSS (v.17.0) statistical software package (SPSS, 2008). The analysis of task performance was based on several common aims. At times it was appropriate to examine the sample’s performance compared to other samples or populations,
upon which examination of means and standard deviations was appropriate. Other methods of analysis involved comparing patient performance over different tasks by transferring results into standardised z-scores based on control group performance. The main analysis technique common to all tasks involved comparing performance of the schizophrenia patients to that of the healthy control group. The analysis techniques for such comparisons underwent the justification outlined in Figure 1.
Figure 1. Analysis Technique Selection for Group Comparisons

1. Spearman's Rank Order
   Correlations
   - Violation of normality
     - 3 groups
     - Covariate
     - No covariate
   - Normally distributed
     - 2 groups
     - No covariate
     - Covariate

2. Pearson's Product Moment
   Correlations
   - Violation of normality
     - 2 groups
     - No covariate
     - Covariate
   - Normally distributed
     - 3 groups
     - No covariate
     - Covariate

3. TASK MEASURES
   - Assess for normality
   - Spearman's Rank Order
     Correlations
   - Pearson's Product Moment
     Correlations

4. Appropriate covariates must involve:
   - Reliable measures
   - Linear relationships with the DV
   - Strong relationships with the DV
   - No significant correlations with other covariates
   - Homogeneity of regression slopes

5. One-way between-groups ANOVA
   - No covariate
   - Covariate
   - Covariate
   - No covariate

6. Independent Samples t-test
   - No covariate
   - Covariate
   - No covariate

7. Mann-Whitney U Test
   - No covariate
   - Covariate
   - No covariate

8. Kruskal-Wallis Test
   - No covariate
   - Covariate
   - No covariate

9. ANCOVA
   - No covariate
   - Covariate
   - No covariate

10. Covariate
    - No covariate
    - Covariate
    - No covariate

11. Covariate
    - No covariate
    - Covariate
    - No covariate

12. Covariate
    - No covariate
    - Covariate
    - No covariate
After the analysis method suitable for group comparison was established, the relationships between task measures and demographic (age, education, pre-morbid IQ) and psychopathological variables (medication, illness duration, age at illness onset, GAF, PANSS positive, negative, general and total ratings) were investigated using either Pearson’s Product Moment or Spearman’s Rank Order Correlation. Considering this involved multiple tests, analyses were subject to Bonferroni adjustment to control for possible inflated Type 1 error. Consequently the alpha level was set to a more stringent level for each comparison (Pallant, 2001). The original alpha level of $p<0.05$, was divided by the number of comparisons intended. Thus, the Bonferroni corrected level for all the demographic variables ($N=3$) was adjusted to $p<0.017$, and for all psychopathological variables ($N=8$) was adjusted to $p<0.006$. If there were any a priori hypotheses regarding the relationship between a demographic or psychopathological variable and task measures, that particular variable was exempt from Bonferroni correction. All significant correlations were interpreted in terms of strength according to Cohen (1977) i.e. small: $r=0.1-.29$, medium: $r=.30-.49$, large: $r=.50-1.0$. The effect of gender on task performance for each group was investigated using two-way between groups ANOVA. This assessed main effects of gender and group as well as the interaction effects between gender and group.

Findings from the analysis are presented statistically either in text or in tables where appropriate. All tables involving means ($M$) and standard deviations ($SD$) are presented as $M (SD)$ unless otherwise indicated. All figures show error bars representing the standard error of measurement.

### 2.5 Summary

This chapter described the two groups of participants involved in this body of work, their recruitment, and inclusion criteria as well as demographic and psychopathological characteristics. Further, this chapter described the testing conditions, procedures, apparatus, task battery and statistical analysis relevant to the following experimental chapters. By describing such details here, this chapter eliminates the necessity for repetition throughout the remainder of the thesis.

This body of work commences with a broad perspective and general investigation into neurocognition and continues on to narrow the focus of the thesis to emotion processing and face processing. Hence, the following chapter will provide background on neurocognition in schizophrenia and investigate performance on tasks involving memory, language, attention, planning, response inhibition and cognitive flexibility.
Chapter 3  Neurocognition in Schizophrenia

3.1  Introduction

This chapter will introduce neurocognition in schizophrenia. This will be followed by presenting empirical data that focuses on replicating basic neurocognitive deficits in schizophrenia. While the emphasis of this thesis is on social cognition, it is important to highlight and reflect upon the consistent neurocognitive impairment shown by schizophrenia patients. There are three main reasons for this. Firstly, impaired neurocognition is a very well established feature of schizophrenia, to the extent that neurocognitive deficits are being considered for inclusion in future diagnostic criteria (Bora et al., 2009; Censits et al., 1997; Keefe, 2008; Keefe & Fenton, 2007). Thus, in relation to this thesis, a basic neurocognitive assessment will allow insight into the prevalent features of the current participant sample. By using common standardised measures it will be possible to ensure that this sample of patients, as well as healthy control participants, perform similarly to other samples, and are thus cognitively representative of wider populations. Secondly, neurocognitive functioning is clearly linked to functional outcome in schizophrenia patients (Green, 1996). The investigation of potential contributors to functional outcome is extremely important when considering the development of potential remediation techniques (Green et al., 2000). Thirdly, and most pivotal to this thesis, neurocognitive performance is strongly correlated with social cognition (Kee et al., 1998a). Researchers have indicated neurocognition and social cognition are two “distinct yet highly related, constructs” (Sergi et al., 2007, p316). This indicates that the relationship between neurocognition and functional outcome is potentially mediated by social cognition. This chapter will discuss each of these three points, beginning with a summary of previous neurocognitive research in schizophrenia, followed by a description of the performance of the current sample; and finally, a discussion of the relationship between neurocognition, social cognition and functional outcome for schizophrenia patients.

3.1.1  Background to Neurocognition in Schizophrenia

Neurocognitive impairment in schizophrenia is well documented (Blanchard & Neale, 1994; Gur et al., 1997) and now considered at the core of schizophrenia (Elvevag & Goldberg, 2000). Impairment is often resistant to antipsychotic medication (Goldberg et al., 1993b). An extensive
literature review of 204 studies revealed that the dysfunction in schizophrenia spans multiple cognitive domains (Heinrichs & Zakzanis, 1998), for example memory, attention and executive functioning. Impairment is apparent early on in illness course with deficits observable in first episode patients (Saykin et al., 1994). Longitudinal studies have revealed no difference in the degree of impairment between first episode and previously treated patients initially, and at 19-month follow-up (Censits et al., 1997). Thus, it is indicated that neurocognitive deficits in schizophrenia are stable over the course of the illness. Deficits in performance are also evident in high-risk individuals’ i.e. first-degree relatives, thus suggesting a familial link (Byrne et al., 1999; Faraone et al., 1995). Schizophrenia patients who show the lowest ratings on global functioning assessments exhibit greater cognitive impairment compared to the higher functioning patients (Loughland et al., 2007). This suggests that cognitive impairment is potentially a major contributor to disability in schizophrenia patients. This data thus provides a clear indication that general cognitive performance is a crucial aspect of schizophrenia pathology.

The literature on neurocognition in schizophrenia is extremely vast; meta-analyses and reviews have attempted to identify broad cognitive domains that appear particularly impaired in schizophrenia (Nuechterlein et al., 2004). Here follows a brief review of the five most significantly impaired domains.

### 3.1.2 Memory

Memory impairment is one of the most replicable and reliable findings in the neurocognitive literature in schizophrenia (Stip, 1996). Both Kraepelin (1919) and Bleuler (1911) implicated memory problems in schizophrenia. Patients with schizophrenia show deficits on a wide range of memory tasks including both short-term memory (STM) and long-term memory (LTM) (Landro et al., 1993). The memory impairment in schizophrenia appears disproportionate compared to other cognitive deficits; several studies utilising wide-ranging neurocognitive test batteries indicate that schizophrenia patients perform worst on the measures requiring memory function (Censits et al., 1997; Rund et al., 2006).

The LTM research in schizophrenia has primarily investigated the verbal, declarative and episodic aspects of LTM using word list learning and passage recall paradigms, with findings clearly indicating impairment in schizophrenia patients compared to normal controls (Cirillo & Seidman, 2003). A meta-analysis encompassing 70 studies confirmed large effect sizes representing significantly impaired verbal and episodic recall and recognition in schizophrenia.
(Aleman et al., 1999), an impairment not moderated by age, medication, length of illness or severity of psychopathology. Deficits on non-verbal tests of declarative LTM have also been observed, indicating generalised memory impairments across multiple modalities (Tracy et al., 2001). As well as episodic declarative problems, semantic memory deficits have also been reported in schizophrenia (Rossell & David, 2006; Rossell et al., 1998). Working memory impairments have also been consistently shown in schizophrenia (Forbes et al., 2006; Lee & Park, 2005). Investigations have revealed deficits in both verbal (phonological loop) and spatial (visuospatial sketch-pad) aspects of working memory (Fuller et al., 2005; Silver et al., 2003).

Structural and functional neuroimaging studies in schizophrenia have implicated several abnormalities in the anatomical structures involved in memory functioning (Shenton et al., 2001). In a review of the literature, Lawrie and Abukmeil (1998) reported reduced brain volume in temporal and hippocampal regions in schizophrenia. Functional imaging studies (Barch et al., 2002) have revealed abnormal activation of the dorsolateral prefrontal and hippocampal regions in schizophrenia patients compared to controls during an episodic memory task. This evidence from neuroimaging work coupled with the extensive neuropsychological work has led researchers to view memory impairment as a core characteristic of schizophrenia (Reichenberg & Harvey, 2007). Furthermore, memory deficits in schizophrenia are directly related to impaired daily living activity (Godbout et al., 2007).

3.1.3 Visuospatial Ability

In addition to memory deficits, schizophrenia patients demonstrate impaired visuospatial ability, even after controlling for IQ (Bozikas et al., 2006b). Many of the visuospatial assessments have been memory based, with deficits shown in working memory (Fleming et al., 1997; Leiderman & Strejilevich, 2004) and delayed memory based tasks (Lewis et al., 2003). Others have found impaired ability to use visuospatial mnemonic strategies (Iddon et al., 1998). Conversely, others have shown visuospatial ability is relatively intact in schizophrenia patients (Lencz et al., 2006). Longevialle-Henin et al. (2005) showed that on two visuospatial embedded figures tasks, overall schizophrenia patients did not differ in performance compared to healthy controls. However, when the patients were split into either low or high disorganised subgroups, the patients showing higher disorganisation demonstrated low accuracy on the visuospatial context processing tasks.
The deficit in visuospatial ability shown by schizophrenia patients has been associated with disturbed electrophysiological correlates of visuospatial processing, particularly in parietal brain regions (Bruder et al., 1998). Visuospatial ability is of functional importance for schizophrenia patients as the implications for daily living are reflected by the relationship between visuospatial associative learning and functional capacity assessed by independent living and community ability (Aubin et al., 2009).

3.1.4 Language

Evidence indicates that schizophrenia patients also demonstrate problems on tasks assessing various aspects of language. Such as an increased number of semantic errors, which are observable in chronic schizophrenia patients (Rossell, 2006) as well as in schizotypal individuals (Johnston et al., 2008a). This abnormality dramatically reduces the ability to convey ideas and engage in meaningful conversations. Furthermore, language disturbance in schizophrenia has also been observed through a reduction in pragmatic conversation skills, which may substantially negatively impact on daily living (Champagne-Lavau et al., 2006). Such skills include processing the non-literal information within an utterance, such as irony or metaphor. Interestingly, impaired pragmatic conversation skills were apparent for schizophrenia patients as well as for the first-degree relatives of these patients (Mazza et al., 2008). Language impairments have been related to delusions and thought disorder in schizophrenia and have been argued by some to be the predicants of these overt positive symptoms (Rossell & Stefanovic, 2007).

3.1.5 Information Processing & Attention

Problems with vigilance, selective attention, switching attention and sustained attention have been well established in schizophrenia patients (Heinrichs & Zakzanis, 1998). As with memory impairment, impaired attention was also noted during the early observations of schizophrenia (Bleuler, 1911; Kraepelin, 1919). Attentional deficits are apparent in both auditory and visual modalities (Baerwald et al., 2001). Many different task designs have been utilised to assess attentional capacity and processing speed in schizophrenia, for example digit-symbol coding (Dickinson et al., 2007), Stroop tasks (Perlstein et al., 1998), backward masking (Saccuzzo et al., 1974), Trail Making and span of apprehension task (Asarnow & MacCrimmon, 1982; Chan et al., 2004a). The most widely used measure however, is the Continuous Performance test (CPT). The CPT paradigm commonly involves the presentation of a series of letters whereby
participants are required to press a button when they view a target letter but refrain from doing so for all other letters. Impairment on CPT tasks have been demonstrated in schizophrenia patients during their first presentation of psychosis, free from medication (Wang et al., 2007) and in chronic patients whereby impairment does not correlate with symptomatology (Kurtz et al., 2001). Deficient attention is also observable in first-degree relatives (Birkett et al., 2007) as well as schizotypal personality types (Gooding et al., 2006). Impaired sustained attention is a key risk marker for schizophrenia, and should be considered a stable enduring trait of the disorder which is independent of clinical presentation (Michie et al., 2000).

Deficient sustained attention in schizophrenia has been correlated with psychophysiological measures. For example, Cullum et al. (1993) revealed performance on the digit cancellation test was correlated with the increased ratio of amplitude of the P50 waveform of the auditory evoked potential. In comparison, measures of learning and memory did not show the same correlations. Neuroimaging evidence suggests differential activation patterns for schizophrenia patients compared to controls during selective attention tasks. Patients have demonstrated reduced activation in dorsolateral prefrontal, anterior cingulate and parietal regions and increased activation in temporal and posterior cingulate regions (Weiss et al., 2007).

3.1.6 Executive Functioning

Executive functioning (often referred to as ‘higher order functioning’) is a broad term used to describe cognitive processes involving control, flexibility, inhibition, regulation, planning and execution of goal-oriented behaviour. Such processes commonly involve abilities mediated by the prefrontal cortex. Extensive research indicates deficient executive functioning in schizophrenia patients (Evans et al., 1997; Morice & Delahunty, 1996). Similar to other cognitive domains, deficits are also apparent during first episode psychosis (Hutton et al., 1998), in first degree relatives (Groom et al., 2008), and schizotypal personality types (Laws et al., 2008).

One frequently used test of executive functioning is the Wisconsin Card Sorting Test (WCST, Heaton, 1981). This task assesses reasoning, planning, and the ability to attain, maintain, and shift cognitive set. Participants are required to match a stimulus card to one of four test cards according to a particular matching principle (i.e. shape, colour). This task has been used extensively in schizophrenia research revealing consistent deficits in performance (Laws, 1999), it is however, somewhat time-consuming. Other frequently used executive functioning tasks that
have revealed performance deficits in schizophrenia include verbal fluency, Stroop colour-word tasks and Trail Making tests (for a review see Johnson-Selfridge & Zalewski, 2001). Further to this, neuroimaging investigations have found schizophrenia patients’ exhibit less blood flow in the prefrontal cortex during executive functioning tasks (Hill et al., 2004). Executive functioning during daily living tasks has also been correlated with negative symptoms in schizophrenia (Semkovska et al., 2004). There are additional wide ranging cognitive impairments in schizophrenia. It is beyond the scope of this thesis to provide an extensive summary of them all.

A number of investigations have indicated a relationship between cognitive ability and symptom severity in schizophrenia. For example, it has been demonstrated that negative symptomatology, i.e. blunted affect, emotional withdrawal etc, is associated with impairment on different aspects of neurocognition (Aleman et al., 1999; Berman et al., 1997; Milev et al., 2005; Voruganti et al., 1997). This will be investigated in the current chapter.

3.2 Aims & Hypotheses

A. To obtain an overview of the cognitive functioning in a sample of schizophrenia patients and compare their performance to a group of healthy control participants. The current battery measured memory (immediate and delayed), visuospatial ability, language, attention and executive functioning.

B. To investigate the relationships between cognitive task performance and the demographic variables (pre-morbid IQ, education, gender and age) as well as the psychopathological variables (medication, PANSS ratings, GAF, age at illness onset and duration of illness)1.

C. To confirm that the current samples were cognitively representative of other schizophrenia patients and control participants by comparing performance with previously published normative data.

D. To assess the relative neurocognitive strengths and weaknesses of schizophrenia patients with regards to the five domains described above.

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1 To avoid repetition, the literature that has previously investigated such relationships, that is, cognitive task performance with demographic and clinical variables, will be presented in the results section for each tool. Thus, the current data will be directly compared with this previous research.
It was hypothesised that schizophrenia patients would show a generalised impairment across all cognitive task measures with performance potentially correlating with negative symptomatology (i.e. PANSS negative score). It was expected patients would perform particularly worse on measures of memory, as indicated in previous literature. Further, it was anticipated that control participants would reveal performance within the accepted ‘average’ range and that the impairment shown by schizophrenia patients would resemble other schizophrenia samples. For each task the analysis will be presented in reference to the first three aims (A,B,C), outlined above. Aim D will be discussed below in section 3.4.

3.3 Neurocognitive Tasks & Performance Results

To examine cognitive impairment in schizophrenia, researchers have utilised task batteries designed to evaluate multiple aspects of neurocognition. Unfortunately, such tools are often relatively expensive, time consuming and arduous for clinical participants to complete (Ryan et al., 1998). Thus, researchers and clinicians have begun to develop concise tools aimed at capturing an overview of performance on neurocognitive domains such as memory, attention, and language (Bralet et al., 2008). Such tools aim to be brief, easily administrable and standardised to test the presence and severity of neurocognitive impairment by comparing performance to control populations. Despite some limitations, the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) has proven to be one such useful tool, and has subsequently been used widely to investigate overall cognitive functioning (Randolph et al., 1998). Consequently, the RBANS was chosen as an overall measure of neurocognitive performance in the current sample of schizophrenia patients. Executive function is not represented in the RBANS. Given the review on the literature and the extensive executive function deficits in schizophrenia, three other measures were also included. These measures assessed planning (Zoo Map), switching/flexibility (Brixton Test) and inhibition (Hayling Sentence Completion Test; HSCT). Each task was administered to the two participant groups detailed in Chapter Two. The following paragraphs describe each of these tools, the previous research into schizophrenia using the same tools and the results of the current sample. To aid fluidity the description, results and discussion for each tool will be presented together. Thereafter, follows a summary of all task performance, providing an overall cognitive profile for the two participant groups demonstrating strengths and weaknesses in performance.
3.3.1 Repeated Battery for the Assessment of Neuropsychological Status (RBANS)

The RBANS is not intended as a thorough neuropsychological assessment, rather a tool which can provide a general, overall evaluation of several domains of cognition (Randolph, 1998). The RBANS comprises of 12 subtests that combine to form a total score and five index scores. Index scores are age-adjusted and standardized such that the normal mean is equal to 100 with a standard deviation of 15. Originally designed as a screening test for dementia, it has become increasingly useful in schizophrenia research. The RBANS has shown test-retest reliability correlations of 0.84 for schizophrenia patients and 0.77 for control participants (Wilk et al., 2002). The RBANS has been used as an early detection measure in psychotic adolescents (Holzer et al., 2007), and as an evaluative tool of cognitive change after cholinergic drug treatment (i.e. rivastigmine; Chouinard et al., 2007), galantamine; (Schubert et al., 2006) and antidepressant treatment (i.e. mirtazapine, Delle Chiaie et al., 2007) in schizophrenia. The RBANS has also been used to investigate the relationship between cognitive impairment and genetic polymorphism in schizophrenia (i.e. COMT, Dickerson et al., 2007) in schizophrenia. The RBANS shows good sensitivity (Chronbach’s alpha=0.88), convergent validity (high correlations with WAIS-III and WMS-III) and test-retest reliability in a schizophrenia population (Gold et al., 1999; Hobart et al., 1999; Weber, 2003; Wilk et al., 2002). Based on a large sample of schizophrenia patients, Wilk et al. (2004) conducted a normative study using the RBANS. It was revealed schizophrenia patients scored approximately 30 points lower (two standard deviations) than the normal mean on the total index score.

Method

The RBANS took each participant approximately 25 minutes to complete. Participants were administered the battery in accordance with the manual guidelines, stimuli were presented from a booklet. The RBANS results were scored by two independent raters using criteria in line with the manual guidelines. Each of the five indexes and associated subtests are described below.

Immediate Memory
a) List Learning – the immediate recall of a list of 10 words over four learning trials. One point for each word of each trial recalled (Total Score Range = 0-40).
b) Story Memory – the recall of a 12 item story over two trials. One point for each item of each trial recalled (Total Score Range = 0-24).
Visuospatial / Constructional
a) Figure Copy – copying a 10 part geometric figure. One point for each part accurately copied and one point for correct placement of each part (Total Score Range = 0-20).
b) Line Orientation – the identification of two target lines out of an array of 13 lines spanning 180 degrees on each of 10 trials. One point for each correctly matched line of each trial (Total Score Range = 0-20).

Language
a) Picture Naming – providing the name of 10 line drawings. One point for each correctly named drawing (Total Score Range = 0-10).
b) Semantic Fluency – the generation of as many exemplars for a given semantic category (e.g. fruits and vegetables) within 60 seconds. One point for each generated exemplar (Total Score Range = 0-40).

Attention
a) Digit Span – the repetition of a string of numbers increasing in length from 2 to 9 digits i.e. 8 trials. Two points for each correctly repeated string or one point if the string must be read a second time (Total Score Range = 0-16).
b) Coding – filling in as many boxes as possible with numbers one to nine that correspond to nine different symbols within 90 seconds. One point for each box filled in with the correct number corresponding to the presented symbol (Total Score Range = 0-89).

Delayed Memory
a) List Recall – free recall of the words from the List Learning subtest. One point for each word recalled (Total Score Range = 0-10).
b) List Recognition – yes/no recognition of 20 words, half of which appeared in the List Learning subtest. One point for each word recognised (Total Score Range = 0-20).
c) Story Recall – free recall of the story from the Story Memory subtest. One point for each item recalled (Total Score Range = 0-12).
d) Figure Recall – free recall of figure from the Figure Copy subtest. One point for each part accurately copied and one point for correct placement of each part (Total Score Range = 0-20).

Results

One-way between-groups analysis of covariance (ANCOVA) was conducted to compare the performance of schizophrenia patients and controls on the six scores of the RBANS, that is the five index scores (immediate memory visuospatial/constructional, language, attention, delayed
memory) as well as the total RBANS score. Participants estimated pre-morbid IQ was used as the covariate as IQ score did correlate with the RBANS measures moderately in both healthy controls ($r=.19-.54$) and schizophrenia patients ($r=.14-.33$), thus providing a theoretically and statistically appropriate covariate. Initially, the ‘number of years of education’ was planned as the covariate in this analysis; however this variable did not correlate with any of the six dependent variables (RBANS measures) for either of the groups. Preliminary checks were conducted to ensure there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariate. There was an issue of normality on two of the six scores for schizophrenia patients and two of the six scores for control participants. Considering the nature of these measures and the even sample sizes, ANCOVA is relatively robust to violations of normality. There were apparent ceiling effects observable on two of the RBANS subtests. For the picture naming subtest, 78% of participants (86% controls, 69% schizophrenia patients) performed at ceiling (scoring 10/10), also 74% of participants (93% controls, 55% schizophrenia patients) performed at ceiling for the List Recognition subtest (scoring 20/20). No floor effects were observed.

A. Group differences: First, group differences in performance were examined. The basic group differences for each individual subtests are included in Table 4. Each subtest combined with at least one other to assess the same underlying domain of cognition. Considering the aim of this chapter was to give more of an overview of generalised cognitive performance, discussion of the group differences will focus on the index scores rather than the subtests.

Table 4. Performance of Schizophrenia Patients and Control Participants on RBANS Subtests

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia ($n=29$)</th>
<th>Controls ($n=29$)</th>
<th>Comparisons$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>List Learning</td>
<td>25.66 (1.03)</td>
<td>32.41 (0.70)</td>
<td>$t(56)=5.44^{**}$</td>
</tr>
<tr>
<td>Story Memory</td>
<td>13.24 (0.81)</td>
<td>18.79 (0.67)</td>
<td>$t(56)=5.29^{**}$</td>
</tr>
<tr>
<td>Figure Copy</td>
<td>14.34 (0.52)</td>
<td>15.24 (0.55)</td>
<td>$t(56)=1.19$</td>
</tr>
<tr>
<td>Line Orientation</td>
<td>16.21 (0.57)</td>
<td>17.69 (0.49)</td>
<td>$t(56)=1.97^{+}$</td>
</tr>
<tr>
<td>Picture Naming</td>
<td>9.55 (0.14)</td>
<td>9.86 (0.07)</td>
<td>$t(40.10)=2.05^{*}$</td>
</tr>
<tr>
<td>Semantic Fluency</td>
<td>19.31 (0.91)</td>
<td>26.72 (1.19)</td>
<td>$t(56)=4.94^{**}$</td>
</tr>
<tr>
<td>Digit-Span</td>
<td>11.45 (0.45)</td>
<td>12.52 (0.55)</td>
<td>$t(56)=1.52$</td>
</tr>
<tr>
<td>Coding</td>
<td>40.62 (1.60)</td>
<td>54.69 (1.76)</td>
<td>$t(56)=5.92^{**}$</td>
</tr>
<tr>
<td>List Recall</td>
<td>5.21 (0.45)</td>
<td>7.69 (0.34)</td>
<td>$t(56)=4.38^{**}$</td>
</tr>
<tr>
<td>List Recognition</td>
<td>19.17 (0.22)</td>
<td>19.93 (0.05)</td>
<td>$t(30.73)=3.42^{*}$</td>
</tr>
<tr>
<td>Story Recall</td>
<td>7.14 (0.48)</td>
<td>10.14 (0.35)</td>
<td>$t(56)=5.05^{**}$</td>
</tr>
<tr>
<td>Figure Recall</td>
<td>9.55 (0.65)</td>
<td>13.17 (0.53)</td>
<td>$t(56)=4.32^{**}$</td>
</tr>
</tbody>
</table>

Note: Mean (standard error) $^1$Comparisons refer to independent samples t-tests.
+ $p=0.054$, * $p<0.05$, ** $p<0.001$
For the general index scores, shown in Table 5, after adjusting for pre-morbid IQ, control participants performed significantly better than the schizophrenia patients on the RBANS total score as well as all index scores except for the visuospatial/constructional index. For example, the magnitude of the group difference on total RBANS score was quite large (partial eta squared=.35); thus 35% of the variance in total RBANS was explained by group. A clear impairment in performance on virtually all the RBANS measures is consistent with meta-analyses indicating broad cognitive impairment in schizophrenia (Heinrichs & Zakzanis, 1998).

Table 5. Comparison of Schizophrenia & Control Participants on RBANS Index Scores

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia patients</th>
<th>Controls</th>
<th>Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=29)</td>
<td>(n=29)</td>
<td>F(1,55)</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>Adjusted</td>
<td>Unadjusted</td>
<td>Adjusted</td>
</tr>
<tr>
<td>mean</td>
<td>mean</td>
<td>mean</td>
<td>mean</td>
</tr>
<tr>
<td>Total</td>
<td>79.86 (2.65)</td>
<td>81.94 (2.25)</td>
<td>102.14 (1.97)</td>
</tr>
<tr>
<td>IM</td>
<td>81.52 (2.77)</td>
<td>82.99 (2.62)</td>
<td>106.07 (2.36)</td>
</tr>
<tr>
<td>VS/C</td>
<td>77.93 (2.74)</td>
<td>80.00 (2.59)</td>
<td>86.17 (2.53)</td>
</tr>
<tr>
<td>LANG</td>
<td>91.41 (2.53)</td>
<td>92.46 (2.61)</td>
<td>111.31 (2.52)</td>
</tr>
<tr>
<td>ATT</td>
<td>88.45 (2.83)</td>
<td>90.28 (3.07)</td>
<td>107.10 (3.23)</td>
</tr>
<tr>
<td>DM</td>
<td>81.83 (3.36)</td>
<td>83.24 (2.57)</td>
<td>99.00 (1.23)</td>
</tr>
</tbody>
</table>

Note: Mean (standard error). *Comparisons refer to one-way analysis of covariance with IQ used as a covariate. IM: Immediate Memory, VS/C: Visuospatial/Constructional, LANG: Language, ATT: Attention, DM: Delayed Memory

* p<0.01, ** p<0.001

B. Correlations with demographics and clinical variables: The second set of analyses was to examine the impact of demographic variables on RBANS performance. As noted, ANCOVA results indicated a strong significant relationship between pre-morbid IQ and total RBANS score (partial eta squared=.16). Overall for all participants, 16% of the variance in the total RBANS score was explained by IQ, with a moderate relationship for schizophrenia patients (r=-.33) and a strong relationship for healthy controls (r=-.55). There were also moderate significant relationships between pre-morbid IQ and visuospatial/constructional (partial eta squared=.13; schizophrenia r=-.27, control r=-.50), as well as attention (partial eta squared=.08; schizophrenia r=-.25, control r=-.33). Interestingly, there were no significant relationships between pre-morbid IQ and immediate memory, language, or delayed memory. Table 5 shows unadjusted and adjusted means for the RBANS measures, indicating the influence that the covariate (pre-morbid IQ) had on performance.

There were no significant correlations between RBANS performance and years of education for either control participants or schizophrenia patients. This is discordant with Gold et al. (1999),
Wilk et al. (2004) and Dickerson et al. (2004) who all found an association between years of education and RBANS performance. It is unclear exactly why the current study failed to reveal such a relationship, however, the number of years of education completed in the current sample was higher than that in other samples which may have obscured any such correlation.

Previous investigations have implicated gender as a potential mediating factor in the cognitive performance of schizophrenia patients. Male schizophrenia patients have been shown to have lower performance than females on tests of executive function, verbal memory and attention (Goldstein et al., 1998). Further, the female schizophrenia patients are reported to show relatively preserved language, verbal memory and visual-spatial function whereas males do not. As a result of such gender effects, a two-way between groups ANCOVA was performed to investigate the role of gender on cognition within the two participants groups. Consistent with the literature above, the main effects of group for each RBANS measure (with the exception of the visuospatial/constructional index) remained, indicating broad impairment for the schizophrenia patients. Further, the analysis indicated a significant main effect of gender on only the visuospatial/constructional index and no other RBANS measure, with males performing better ($M=85.35$, $SD=16.48$) than females ($M=77.38$, $SD=10.27$) overall. This is in line with Gold et al. (1999) and Wilk et al. (2004) who also revealed a male superiority on this index. Interestingly however, Wilk et al. also found males performed better on the attention index, and females performed better on the delayed memory index, neither of these findings were supported by the current data. Upon inspection of the interaction between gender and group, the analysis revealed no significant interactions for any of the RBANS measures. Thus indicating no differences in the effect of gender on cognitive performance for schizophrenia patients and controls; male and female schizophrenia patients showed the same pattern of performance as male and female control participants on the RBANS. It must be noted that these results should be interpreted with some caution as the genders were not equally represented within the groups, and that there were more male than female patients.

The relationship between age and RBANS performance was also investigated for the two participant groups. Pearson product-moment correlation coefficients indicated no significant correlations between age and any of the RBANS measures for control participants. This was not unusual as the RBANS scores are age-scaled. For the schizophrenia patients however, there were correlations between age and attention ($r=0.54$, $p<0.01$), and delayed memory ($r=0.48$, $p<0.01$). Performance on these index scores tended to decrease with age. Other researchers
have found positive correlations between age and attention (Wilk et al., 2004), and between age and language (Gold et al., 1999). However, rather than actual differential age effects for schizophrenia patients, it was possible that the younger patients of the current sample were performing worse on RBANS measures not because they were younger but because they were more unwell than older patients. As discussed in Chapter 2, there were significant negative correlations between age and symptom ratings for the schizophrenia patients. Therefore, the impaired cognitive performance may have actually been more a consequence of psychopathology rather than age. Symptom effects have certainly been shown to relate to cognitive functioning; Dickerson et al. (2004) revealed the PANSS negative rating as a significant predictor of RBANS total score. Such relationships within the current data were further explored by investigating the Pearson product-moment correlation coefficients between RBANS measures and PANSS ratings as well as other clinical characteristics including medication, age at illness onset, illness duration and GAF (Bonferroni corrected \(p<0.017\)). In line with expectations, the results indicated significant negative correlations between RBANS measures and PANSS negative (attention \(r=-.46\)), PANSS general (immediate memory \(r=-.46\); delayed memory \(r=-.49\); total score \(r=-.51\)) and PANSS total scores (immediate memory \(r=-.49\); delayed memory \(r=-.54\); total score \(r=-.51\)). The visuospatial/constructional and language index scores did not show any correlations with PANSS ratings, nor did any RBANS measure correlate with the PANSS positive factor. These results provide support for the notion that the age effects discussed above were actually indeed more a consequence of the inverse relationship between PANSS ratings and cognitive functioning. Such relationships are consistent with existing literature (Braff et al., 1991; Sanfilipo et al., 2002; Sharma & Antonova, 2003). Other patient characteristics such as medication level, illness duration and GAF scores showed no significant correlations with any of the RBANS measures.

C. Comparisons with other samples: The performance of the current sample was contrasted with other samples from the literature. The RBANS index and total scores are standardised such that average, normal performance reveal scores of 100±15. Thus, Table 5 illustrates that the control participants from the current sample were indeed representative of the wider population with performance falling within this average, normal range. Table 6 shows the results from the current patient sample as well as two other larger schizophrenia samples. The Wilk et al. (2004) sample of \(N=575\), revealed performance of the schizophrenia group that was approximately two standard deviations below the normal mean. However, Loughland et al. (2007) in a sample of \(N=285\), indicated that schizophrenia performance was only three-quarters of a standard
deviation below the normal mean. Overall, the RBANS total score performance of the current schizophrenia sample was relatively equidistant from these two other schizophrenia samples. On closer inspection of the index scores, the results on immediate memory, language, attention and delayed memory most resemble those from Loughland et al. Conversely, the performance on the visuospatial/constructional index score was very similar to Wilk et al. The performance level of the control participants was also slightly below normal levels on this index score ($M=86.17$, $SD=13.62$). One explanation for this finding may be that the two independent raters who scored the subtests interpreted the scoring guidelines differently to others and employed a potentially stricter criterion on subtests requiring more subjective scoring. This could have particularly impacted scores on the figure copy subtest of the visuospatial/constructional index. This scoring criterion however, was the same for both control participants and schizophrenia patients, and thus does not greatly impact on the group comparison of neurocognition which was the main aim for this chapter.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Total Score</td>
<td>79.86(14.29)</td>
<td>88.72(16.35)</td>
<td>70.54(14.80)</td>
</tr>
<tr>
<td>Immediate Memory</td>
<td>81.52(14.93)</td>
<td>83.83(17.84)</td>
<td>71.84(18.43)</td>
</tr>
<tr>
<td>Visuospatial / Constructional</td>
<td>77.93(14.76)</td>
<td>96.69(17.82)</td>
<td>78.63(18.29)</td>
</tr>
<tr>
<td>Language</td>
<td>91.41(13.61)</td>
<td>95.72(13.19)</td>
<td>84.53(14.33)</td>
</tr>
<tr>
<td>Attention</td>
<td>88.45(15.24)</td>
<td>96.16(16.47)</td>
<td>73.17(16.86)</td>
</tr>
<tr>
<td>Delayed Memory</td>
<td>81.83(18.07)</td>
<td>84.72(20.35)</td>
<td>73.86(19.05)</td>
</tr>
</tbody>
</table>

Patients from the current sample and those from Loughland et al. (2007) predominantly involved outpatients of similar age and illness onset. However, the current sample revealed somewhat lower ratings on the NART, GAF and PANSS. The recruitment source and functioning level of patient samples can greatly influence the cognitive performance observed in schizophrenia (Loughland et al., 2007). Thus, the fact that the current sample appeared to be slightly more unwell than that of Loughland et al., may account for the slightly lower performance on the RBANS. In comparison, the Wilk et al. (2004) sample was recruited from a treatment setting (some as inpatients), and thus characterised by even lower functioning and hence lower cognitive performance. This comparison has highlighted that the current sample of patients revealed levels of cognitive functioning within the range of other larger groups of schizophrenia patients, and can thus be considered a relatively cognitively representative patient group. Further, as indicated, the control participants also appear representative of average cognitive performance.
The Zoo Map test is part of the Behavioural Assessment of the Dysexecutive Syndrome (BADS) test battery (Wilson et al., 1996). It has been found to be a valid and sensitive tool to examine performance in the schizophrenia population (Katz et al., 2007). The Zoo Map assesses route planning ability (an important aspect of executive functioning) and aims to reflect daily life scenarios, and is thus considered an ‘ecologically valid’ task. The Zoo Map has been used as a measure of planning ability in normal ageing (Allain et al., 2005) and dementia (Allain et al., 2007) as well as brain injury (Wood & Liossi, 2006). Recent applications of the Zoo Map in schizophrenia have involved the relationship of executive functioning and the ability to cope with psychotic symptoms (Bak et al., 2008) as well as investigations into the presence of executive dysfunction in schizotypal personality types (Laws et al., 2008).

**Method**

The Zoo Map took each participant approximately 10 minutes to complete. Participants were given a map of a zoo and instructions to draw a route around the zoo to visit six out of 12 possible locations (i.e. Elephant’s house, Llama enclosure) as well as the rules they were required to follow (i.e. start at the entrance, using certain paths only once). There were two trials each with different instructions. The first trial (T1) involved a ‘high demand’ version, whereby participants were not given the order in which to visit the locations, and thus were required to carefully plan their route in advance to minimise errors. Errors were recorded if the participant broke one of the rules or missed a location they were required to visit. The second trial (T2) was ‘low demand’ whereby participants were given more detailed step-by-step instructions regarding the order they were required to travel around the zoo. The difference in performance over the two trials highlighted the participants’ ability to spontaneously plan with limited structure (Formulation condition) compared to their ability to follow a concrete, highly structured strategy (Executive condition). Participants received a profile score (ranging from 0-4) based on the number of locations that were visited in the correct sequence, the total number of errors made and the time taken to plan and execute the task.
Typical parametric statistics were not appropriate due to non-normal distribution of the Zoo Map scores. As a result, Mann-Whitney U tests were conducted to compare the performance of schizophrenia patients and controls on the five measures of the Zoo Map: sequence score T1, error score T1, sequence score T2, error score T2, and overall profile score.

A. As indicated in Table 7, there were no significant differences in performance between controls participants and schizophrenia patients on the Zoo Map. Intact schizophrenia performance on this task has also been demonstrated by both Cools et al. (2000) and Evans et al. (1997).

Further analysis was completed to determine whether the two participant groups differed in performance over the high and low demand trials of the task. Considering there is no non-parametric alternative method to explore this, exploratory analysis was conducted using parametric statistics. A mixed between-within analysis of variance (ANOVA) was conducted, with group as the between-subject factor and demand (high: sequence score T1, vs. low: sequence score T2) as the within-subject factor. The analysis revealed a main effect of demand ($F(1,56)=46.48, p<0.001$), indicating that as expected participants found the high demand trial harder than the low demand trial. There was however, no interaction between demand and group indicating that this pattern of performance was the same for both control participants and schizophrenia patients. Again no overall group effect was observed. Comparative analysis using error scores was not completed due to the small number of errors made overall for both groups.

| Table 7. Comparison of Schizophrenia Patients and Control Participants on the Zoo Map |
|-----------------------------------------|-----------------------------------------|---------------|
| Schizophrenia n=29 | Controls n=29 | Comparisons$^1$ |
| Sequence score T1  | 5.62 (2.37) | 5.75 (2.53) | $z = -0.74$ |
| Error score T1     | 0.93 (1.22) | 0.48 (0.51) | $z = -0.32$ |
| Sequence score T2  | 7.93 (0.37) | 7.90 (0.56) | $z = -1.22$ |
| Error score T2     | 0.21 (0.41) | 0.07 (0.26) | $z = -0.03$ |
| Profile score      | 3.00 (0.85) | 3.17 (0.80) | $z = -1.51$ |

Note: "Comparisons refer to Mann Whitney U Tests, all non-significant"

B. Spearman’s Rank Order Correlations revealed no significant correlations between Zoo Map scores and pre-morbid IQ, education, or age for either participant group. Two-way between groups ANOVA indicated there was also no effect of gender on task performance, nor any
gender by group interactions. Further, for the schizophrenia patients, there were no significant correlations between Zoo Map scores and PANSS ratings, medication, age at illness onset, illness duration, or GAF.

C. Although the results from the current sample showed intact performance of schizophrenia patients, the actual overall profile scores (of both participant groups) were relatively different to other studies. For example, Evans et al. (1997) reported profile scores for schizophrenia patients of $M=1.00$ ($SD=1.41$) and for controls $M=1.72$ ($SD=1.49$). In comparison, Katz et al. (2007) also reported lower profile scores for chronic patients ($M=0.52$, $SD=0.81$), acute patients ($M=1.63$, $SD=1.24$), and controls ($M=2.54$, $SD=1.14$), however, this reflected a significant difference in performance between patients and controls. Initially, Krabbendam et al. (1999) also revealed a significant difference in performance between schizophrenia and control participants, however, once schizophrenia patients exhibiting low IQ were excluded from the analysis this difference was no longer apparent. While the current samples showed no significant differences in performance their results were substantially higher than other samples. Better performance was not only apparent for the patient sample but also for the controls, who performed up to 18% better than the normative sample reported in the test manual (Wilson et al., 1996). Therefore, the increase in performance was not simply due to a higher functioning patient group, rather observable over all participants. This may reflect a subjective scoring difference; however, the results from all other studies report relatively large standard deviations. Therefore, this wide variability in task performance between studies suggests that the Zoo Map may not provide a particularly reliable indicator of participant performance. The results of the current data indicate intact executive functioning, in terms of planning ability, which is inconsistent with the majority of the literature (Laws, 1999). In retrospect although ecologically valid, this task may not be adequately sensitive enough to assess executive functioning, particularly planning, in schizophrenia when used in isolation; the WCST is most likely to a better alternative, however, time requirements prevented its use in the current study.

3.3.3 Hayling Sentence Completion Test (HSCT)

The HSCT is an executive functioning task designed to assess basic initiation speed (section one) and response inhibition (section two) (Burgess & Shallice, 1997). This task has been used previously in schizophrenia samples in a variety of investigations. The majority of the literature documenting performance of schizophrenia patients on the HSCT has indicated impaired
response initiation and suppression (Groom et al., 2008; Nathaniel-James et al., 1996; Waters et al., 2003). Other investigations have included testing the relationship between executive functioning and clinical presentation (Chan et al., 2004b), as well as neuroimaging investigations (McIntosh et al., 2008). Furthermore, the HSCT has been used to examine performance in schizotypal personality (Laws et al., 2008), early-onset psychosis (Groom et al., 2008) and high risk factors for schizophrenia (Byrne et al., 1999).

Method

The HSCT took each participant approximately 5 minutes to complete. The task involved two sections. In each section the investigator reads aloud 15 sentences with the last word omitted i.e. ‘the old house will be torn…’. In section one, participants were required to complete the sentence as sensibly and quickly as possible i.e. ‘the old house will be torn… down’. In section two, participants were required to nonsensically complete the sentence as quickly as possible by giving a word that does not fit in the context of the sentence i.e. ‘the old house will be torn… banana’. This requires suppression or inhibition of the immediate response and then generation of an alternative response. For each section the response latencies for the 15 sentences were recorded and summed to produce a total time. Participants were also scored on error rates for section two. Category A errors were scored when participants provided a sensible completion of the sentence (when the response should be unconnected to the sentence) i.e. ‘most cats see very well at… night’. Category B errors were scored when participants provided a word which was somewhat semantically related to the sentence but not a typical direct completion i.e. ‘most cats see very well at… midday’ or ‘most cats see very well at… dogs’. The total time scores and the error scores were transformed into scaled scores and then summed to provide an overall scaled score ranging from 1 (impaired) to 10 (very superior). The five scores obtained from the task are presented in Table 8.

Results

Upon inspection of the data, violations of normality for the HSCT measures for the two participant groups were apparent. However, examination of histogram plots indicated these

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2 The data from this task are part of a larger study which has been peer-reviewed and published: (Joshua et al., 2009).
violations were not extreme and the sample sizes were equal, consequently group differences were pursued using parametric tests.

A. Independent samples t-tests revealed significant differences in performance between schizophrenia patients and control participants on all measures of the HSCT. Table 8 indicates schizophrenia patients showed deficits on initiation and suppression of response, and demonstrated more errors during the task.

According to the classification guidelines (Burgess & Shallice, 1997), on each of the HSCT measures, controls consistently performed at either average or high average levels, whereas the schizophrenia patients performed at moderate average levels. Thus, although there was a significant difference in performance between the two groups, the schizophrenia patients were not considered to demonstrate low average, poor, abnormal or impaired performance as classified in the task guidelines.

Table 8. Comparison of Schizophrenia Patients and Control Participants on the HSCT

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia (n=29)</th>
<th>Controls (n=29)</th>
<th>Comparisons(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1 scaled score</td>
<td>5.24 (1.43)</td>
<td>6.14 (0.79)</td>
<td>(t(43.60)=2.96^*)</td>
</tr>
<tr>
<td>Section 2 scaled score</td>
<td>5.38 (0.98)</td>
<td>6.41 (1.02)</td>
<td>(t(56)=3.94^{**})</td>
</tr>
<tr>
<td>Section 2 error score</td>
<td>5.48 (2.25)</td>
<td>6.93 (1.36)</td>
<td>(t(46.12)=2.97^*)</td>
</tr>
<tr>
<td>Total scaled score</td>
<td>16.07 (3.22)</td>
<td>19.48 (2.16)</td>
<td>(t(49.04)=4.74^{**})</td>
</tr>
<tr>
<td>Overall scaled score</td>
<td>5.21 (1.54)</td>
<td>6.93 (1.51)</td>
<td>(t(49.04)=4.74^{**})</td>
</tr>
</tbody>
</table>

Note: \(^1\)Comparisons refer to independent samples t-tests

\(^*\)\(p<0.01\), \(^{**}\)\(p<0.001\)

B. Previous investigations into schizophrenia using the HSCT have included pre-morbid IQ and/or years of education as covariates in the analysis (Byrne et al., 1999). However, the current data showed only weak, non-significant correlations between these variables and the HSCT measures. Therefore, for the current participant groups, pre-morbid IQ and education did not significantly relate to task performance, rendering them inappropriate covariates for analysis.

There were no effects of gender on the HSCT measures, with one exception that females (\(M=7.04, SD=1.40\)) demonstrated a higher error scaled score (i.e. fewer errors) on section two of the task than males did (\(M=5.62, SD=2.13; F(1,54)=4.68, p<0.05\)). There was no gender by group interaction for any of the HSCT measures, indicating males and females from the two different groups performed similarly. Pearson product moment correlation coefficients also indicated no relationship between task performance and age for either participant group. For the
schizophrenia group, there were no significant correlations between the HSCT measures and medication, age at illness onset, illness duration, GAF, or PANSS scores.

C. The current participants showed similar performance on the HSCT compared to other samples in the literature. For example, control participants have revealed an average total scaled score of 18.04, compared to the current controls scoring at 19.48 (McIntosh et al., 2005). Similarly, schizophrenia patients from the same study revealed an average total scaled score of 15.54, compared to the current schizophrenia patients at 16.07. While the McIntosh et al. results did not reflect group differences in performance, the current study as well as several others did show schizophrenia patients were significantly impaired compared to controls (Byrne et al., 1999; Marczewski et al., 2001; Nathaniel-James et al., 1996; Waters et al., 2003).

In summary, results from the HSCT indicated schizophrenia patients do show impaired response initiation and inhibition, this was established using a brief, simple method of assessment.

3.3.4 The Brixton Spatial Anticipation Test (Brixton Test)

The Brixton Test is an executive functioning task that assesses detection, abstraction and use of rules (Burgess & Shallice, 1997). This task measures similar abilities as the WCST, however, has the advantage of being quicker and easier to administer and score. While the task has been used extensively in brain-damaged populations (Wood & Liossi, 2006), there appears to be limited work using the Brixton Test with schizophrenia samples (Drake & Lewis, 2003; Marczewski et al., 2001).

Method

The Brixton Test took each participant approximately 5 minutes to complete. The test consisted of a booklet with 56 pages showing an array of ten numbered circles (two rows of five). On each different page one of the ten circles was filled in, the position of this filled in circle changed on each page. Participants were shown one page at a time and were required to predict what position the filled in circle would be on the subsequent page. To respond correctly the participants must have identified a changing pattern based on the position of the preceding filled in circle. The number of errors was totalled and translated to a scaled score ranging from one (impaired) to 10 (very superior).
Results

A. One-way between-groups ANCOVA was conducted to compare the performance of schizophrenia patients and controls on the Brixton Test. There was an issue of normality on the task measures however, ANCOVA is relatively robust to such violations so was carried out for group comparisons whereas Spearman’s Rank Order Correlations were used to investigate relationships between task performance and other demographic and psychopathological measures. Upon initial inspection of the data, there were moderate correlations between participants’ age and the Brixton error score and scaled score, for controls ($r=.55$, $p<0.01$; $r=-.53$, $p<0.01$ respectively) and schizophrenia patients ($r=.30$, ns; $r=-.28$, ns respectively). This indicated increased age resulted in more errors, and thus worse overall performance, consequently age provided a theoretically and statistically appropriate covariate to include in the analysis. There were no correlations with pre-morbid IQ, and was thus eliminated as a potential covariate.

The ANCOVA revealed that after adjusting for the effects of age, there were significant differences between the groups on Brixton error score as well as the scaled score. The magnitude of the group difference was quite large (error score: partial eta squared=.18, scaled score: partial eta squared=.16). Table 9 indicates that schizophrenia patients demonstrated more errors, resulting in a lower overall score than control participants. While controls showed high average performance according to the classification guidelines (Burgess & Shallice, 1997), the schizophrenia patients showed moderately average performance.

Table 9. Comparison of Schizophrenia Patients and Control Participants on the Brixton Test

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia</th>
<th>Control</th>
<th>Comparisons$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n=29$</td>
<td>$n=29$</td>
<td>$F(1,55)$</td>
</tr>
<tr>
<td>Error score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted mean</td>
<td>16.97 (1.34)</td>
<td>12.21 (1.11)</td>
<td>11.79*</td>
</tr>
<tr>
<td>Adjusted mean</td>
<td>17.40 (1.15)</td>
<td>11.78 (1.15)</td>
<td></td>
</tr>
<tr>
<td>Scaled score</td>
<td>5.66 (0.45)</td>
<td>7.10 (0.35)</td>
<td>10.19*</td>
</tr>
<tr>
<td>Unadjusted mean</td>
<td>5.52 (0.38)</td>
<td>7.24 (0.38)</td>
<td></td>
</tr>
<tr>
<td>Adjusted mean</td>
<td>5.52 (0.38)</td>
<td>7.24 (0.38)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Mean (standard error). $^1$Comparisons refer to one-way analysis of covariance with age as the covariate. $^*p<0.01$

B. The results confirmed a strong significant relationship between age and the Brixton error score (partial eta squared=.16) as well as the scaled score (partial eta squared=.15). Approximately 15% of the variance in the Brixton measures was explained by age. Table 9
shows unadjusted and adjusted means for the Brixton measures, indicating the influence of the covariate (age) on performance.

Spearman’s Rank Order Correlations revealed no significant relationships between Brixton performance and pre-morbid IQ or education. There were no effects of gender on the task, nor any interactions between gender and group. Males and females demonstrated equivalent performance within the two groups. For the schizophrenia patients, there were no significant correlations between task performance and medication, age at illness onset, duration of illness, GAF, or PANSS scores.

C. The total number of errors for the current control group ($M=12.21, SD=6.00$) was similar to other samples (Marczewski et al., 2001); $M=12.9, SD=4.5$. For the schizophrenia patients however, the current sample produced less errors ($M=16.97, SD=7.24$) than other patients ($M=29.8, SD=13.8$) (Marczewski et al., 2001). Marczewski et al. included only 15 patients, and did not present details of the patient symptom characteristics or level of functioning relating to the sample, this unfortunately makes comparisons difficult. Furthermore, no relationship with age was reported by Marczewski et al. The few studies that have used the Brixton Test in schizophrenia have not provided details on average group performance. Thus, additional research is required to determine typical Brixton Test performance by schizophrenia patients. The Brixton Test has been used in other clinical groups, for example patients with structural brain damage after head trauma (Wood & Liossi, 2006), as well as patients with major depression (Gohier et al., 2009). Comparisons on the total scaled score indicated the schizophrenia patients from the current sample demonstrated similar performance ($M=5.66, SD=2.42$) to patients with damage to bifrontal cortical regions ($M=5.60, SD=2.21$). Similarly, comparisons on the total error score indicated schizophrenia patients demonstrated similar performance ($M=16.97, SD=7.24$) to patients with major depression ($M=16.29, SD=7.64$).

In summary, the results of the Brixton test indicated schizophrenia patients show impairment in the ability to detect and utilise a changing pattern of rules during a visuospatial sequencing task.

### 3.4 Neurocognitive Strengths & Weaknesses in Schizophrenia

Aim D was to examine the relative strengths and weaknesses of the schizophrenia sample. As the various assessment methods differed in scoring range, raw scores were transformed into standardised z-scores based on the means and standard deviations of the control participants.
Figure 2 summarises the degree of impairment demonstrated by schizophrenia patients compared to control performance over the different neurocognitive assessments.

The tasks utilised in the current body of work assessed overlapping aspects of neurocognition, therefore, z-scores were developed based on composite measures of the five domains discussed in section 3.1. A memory domain was calculated from the immediate and delayed memory subscales of the RBANS, the visuospatial, language and attention domains were also from the RBANS, and the executive functioning domain was calculated from the Zoo Map, HSCT and Brixton test. Repeated measures ANOVA indicated that the schizophrenia group demonstrated performance below the control average on all measures of neurocognition \(F(1,56)=48.01, \ p<0.001\). Post-hoc independent samples t-tests confirmed deficits on memory \(t(56)=6.05, \ p<0.001\), visuospatial \(t(56)=2.21, \ p<0.05\), language \(t(56)=5.58, \ p<0.001\), attention \(t(56)=4.34, \ p<0.001\), and executive functioning \(t(56)=3.78, \ p<0.001\). It must be noted, performance of the schizophrenia patients on the Zoo Map was not significantly impaired compared to controls and this was inconsistent with previous investigations into planning. Considering this measure
contributed to the composite executive functioning domain, this may have resulted in a slight under-estimation of the impairment shown by schizophrenia patients.

Further analysis revealed a significant interaction between group and neurocognitive domain (\(F(4,224)=8.06, p<0.001\)), indicating schizophrenia patients were indeed more impaired on some domains than others. As shown in Figure 3, performance of the schizophrenia patients was within one standard deviation of control performance on the visuospatial/constructional and executive functioning domains, followed by attention, then language, and lastly memory, which was up to 2.3 standard deviations from control performance.

![Neurocognitive Domain](image)

Post-hoc paired samples t-tests (Bonferroni corrected \(p<0.005\)) for the schizophrenia patients indicated performance was worst on the memory domain, with significant impairment compared to the visuospatial/constructional (\(t(28)=5.71, p<0.001\)), attention (\(t(28)=4.07, p<0.001\)) and executive functioning domains (\(t(28)=4.70, p<0.001\)). Performance on the language domain was the second worst, with significantly greater impairment than the visuospatial (\(t(28)=4.09, p<0.001\)) and executive functioning domains (\(t(28)=-3.33, p<0.005\)).
3.5 Discussion

The results presented satisfy the aims and hypotheses of this chapter detailed in section 3.2. As expected, schizophrenia patients did reveal a generalised neurocognitive impairment. Patients demonstrated significantly poorer performance than control participants on all task measures (with the exception of the Zoo Map). The RBANS proved a useful tool in distinguishing performance of schizophrenia patients from control participants on measures of memory, language, and attention. Although RBANS provided a valuable measure to examine general cognitive ability, there were some ceiling effects on individual subtests indicating some aspects of the RBANS may be inadequately demanding in a schizophrenia sample. The HSCT revealed schizophrenia patients displayed difficulty in the inhibition of inappropriate responses, whereas the Brixton Test revealed impairment in cognitive flexibility. The Zoo Map however, did not appear to be sensitive enough to detect deficits in planning in schizophrenia patients, a finding established in other reports.

There were significant effects of IQ on neurocognitive performance evidenced only by the RBANS, and not the three executive function tasks i.e. Zoo Map, HSCT or Brixton test. While higher IQ was associated with better performance on assessment of visuospatial/constructional ability and attention, less of an effect of IQ was apparent for memory and language assessment. With a few exceptions, there were minimal associations of neurocognitive performance and education, age or gender for healthy controls or schizophrenia patients.

There was no relationship between task performance and medication dosage for schizophrenia patients. As expected, however, performance on some measures was correlated with negative symptomatology as measured by the PANSS negative score. This finding is consistent with previous work (Dickerson et al., 2004). Schizophrenia patients who exhibit more symptoms such as flat affect, emotional withdrawal, and poor rapport also performed worse on measures of neurocognition. This was not observable for those patients exhibiting more positive symptoms such as delusional thinking or hallucinations. The current data in contrast to predictions did not reveal an association between neurocognitive functioning and GAF. The GAF is a relatively simple and subjective assessment encompassing personal, family and occupational functioning. While it is a useful tool to gain an overall view of wellbeing, it may not have been sensitive enough to reveal specific relationships between neurocognition and functioning. A more
complex measure including specific ratings on social integration, work ability and personal health and hygiene may have been better able to explore such relationships.

A generalised impairment in task performance was observable in schizophrenia patients, however, as predicted patients were particularly impaired on measures of memory. Additionally, the overall cognitive performance of patients did resemble that of other Australian schizophrenia samples as discussed in each of the task results sections. Thus, it was confirmed that the patients involved in this work were cognitively representative of other schizophrenia patients. Further, the control participants involved in this study also exhibited performance within the accepted ‘average’ range as compared to previously published normative data.

3.5.1 Limitations

There were several limitations to the current body of work. As discussed, some aspects of the RBANS involved somewhat subjective ratings, this may have impacted on the assessment of some aspects of neurocognition, slightly skewing the results, albeit for both participant groups. Furthermore, the Zoo Map test did not appear to be adequately sensitive enough to reveal the executive functioning problems typical of schizophrenia patients which would have been better tested via the WCST. As indicated in the previous chapter, the two participant groups were not balanced for gender which may have concealed any effects particularly related to male vs. female performance. Lastly, as suggested above, the current body of work may have been improved by including more detailed assessment of functioning of the schizophrenia sample.

3.5.2 Implications of Impaired Neurocognition in Schizophrenia

While the neurocognitive deficits observable in schizophrenia are well established, the implications of these deficits are not usually discussed. Researchers have begun to investigate how impaired neurocognition actually affects day-to-day life, i.e. the functional consequences of neurocognitive deficits. It has been reported that the neurocognitive deficits in healthy elderly individuals can predict activities of daily living (Moritz et al., 1995). Likewise, reviewing the schizophrenia literature shows that neurocognitive capacity is clearly linked to functional outcome (Green, 1996; Green et al., 2000). Specifically, verbal memory has been associated with community outcome, social problem solving and social skill acquisition. Further, vigilance and card sorting ability also predicted some such aspects of functional outcome. Interestingly, the
relationship between neurocognitive impairment and functional outcome was much stronger than that between psychotic symptomatology and functional outcome. Improvements in memory function after clozapine treatment have been associated with improved quality of life and level of functioning (Buchanan et al., 1994) and better cognitive flexibility has been related to improved social functioning (Wykes et al., 1999). Thus, there is relatively strong evidence to suggest that neurocognitive functioning may indeed be a limiting factor in the functional outcome schizophrenia patients.

These findings provide direct implications for the treatment of schizophrenia (Medalia & Lim, 2004). Understanding which neurocognitive deficits compromise functional outcome assists in determining which areas of neurocognition are best targeted for remediation. Further, considering the wide heterogeneity in neurocognitive performance in schizophrenia, it may be appropriate to tailor remediation tools to an individual’s cognitive strengths and weaknesses (Green et al., 2000).

3.5.3 Neurocognition & Social Cognition

As demonstrated, neurocognitive tasks typically involve letters, numbers, words, inanimate objects and generally static stimuli; this is in comparison, to social cognition. Social cognition is usually tested via tasks involving personally relevant, context-dependent and changing stimuli (Fiske & Taylor, 1991). Neurocognition and social cognition are related, however, separate constructs (Sergi et al., 2007). Both the terms neurocognition and social cognition clearly imply a neurological basis, however, involve different triggering events and associated meaning. Thus, social cognition and neurocognition are theoretically and statistically best considered as two separate constructs rather than one (Penn et al., 1997; Sergi et al., 2007). Strong correlations between social cognition and neurocognition (.91) have been confirmed (Vauth et al., 2004), indicating that aspects of social cognition rely on neurocognitive foundations. Relationships have been demonstrated between social cognition measures (such as emotion processing and social perception) and attention (Addington & Addington, 1998), early visual processing (Kee et al., 1998a), executive functioning (Bryson et al., 1997), memory and language (Sachs et al., 2004; Schneider et al., 1995). This will be discussed in greater detail in the following chapter.

As discussed in 3.5.2, impairments in neurocognition clearly relate to poorer functional outcome in schizophrenia. Others have discussed the strong link between impairments in social cognition
and functional outcome (Couture et al., 2006). For example, associations are observable between emotion processing in schizophrenia and work functioning/independent living (Kee et al., 2003). Further, correlations between emotion processing and social competence have also been reported in schizophrenia (Mueser et al., 1996). The evidence suggests poor social cognition can lead to poor social interaction and consequently poorer functional outcome.

Considering 1) functional outcome in schizophrenia appears to be in part explained by neurocognition, 2) functional outcome in schizophrenia also appears to be in part explained by social cognition, and 3) that individuals with poorer neurocognition are likely to also show impaired social cognition (Bell et al., 2008), recent work has begun to directly investigate this three-way relationship statistically. Some authors have suggested social cognition actually plays a mediating role in the relationship between neurocognition and functional outcome in schizophrenia (Green et al., 2000; Green & Nuechterlein, 1999; Kee et al., 1998a). Structural equation modelling techniques have been utilised to investigate whether neurocognition has a direct impact on functional outcome or whether the impact is in reality indirect and mediated by social cognition (Sergi et al., 2006; Vauth et al., 2004). Findings have confirmed the latter to be more accurate. Likewise, using emotion processing as a measure of social cognition, others have also revealed that the effects of neurocognition on functional outcome were entirely mediated by social cognition (Brekke et al., 2005). Further, social cognition showed direct effects on functional outcome as well as indirect effects mediated by social competence and social support. Basic neurocognition is required for social cognition, and social cognition is consequently required for aspects of social functional outcome (Green & Nuechterlein, 1999). Such theoretical models have helped develop framework in which to understand the limits on functional outcome in schizophrenia and thus develop better remediation tools.

The implication of social cognition as a mediator to functional outcome has resulted in growing research in the area, with suggestions that social cognition may be a more logical target for remediation that neurocognition (Green et al., 2000). While research is increasing, the underlying deficits in social cognition in schizophrenia still require further exploration. Social cognition incorporates several different domains (such as emotion processing, social perception, theory of mind, social problem solving, attributional bias), each of which have been tested via various types of different tasks. The fashion in which these domains integrate together and influence functional outcome is yet to be comprehensively explored.
3.6 Summary

This chapter has provided findings to indicate schizophrenia patients show a generalised impairment in neurocognitive performance compared to control participants which in some instances was related to negative (and not positive) symptomatology. This impairment was greatest on measures of memory ability with less impairment on visuospatial / constructional measures. The schizophrenia and control participants assessed within this body of work show neurocognitive profiles similar to other samples, and thus may be considered representative of the respective wider populations. The link between basic neurocognition and functional outcome was briefly discussed with suggestions that social cognition may play a role as a mediating factor in this relationship. Consequently, the following chapters will explore the performance of the two participant samples on measures of social cognition, beginning with emotion processing.
Chapter 4  Emotion Processing in Schizophrenia

The previous chapter detailed the impairment in schizophrenia on measures of non-social cognition or what is termed ‘cold cognition’ (Wolwer et al., 2005). This chapter will shift the focus to aspects of social cognitive functioning. As previously noted, social cognition refers to the cognitive capacity for processing of social information required for skilful social interaction.

4.1 Background to Social Cognition

Humans, and other mammals live amongst multiple members of the same species, thus humans are inherently social beings. From an evolutionary perspective, societal living increases the chances of survival by improving safety from predators, providing more mate options and increasing food supply. The implications of a social existence within modern the age has expanded with technological advances resulting in increasingly complex and wide-ranging social networks. Our ability to successfully exist in a social setting involves both automatic and controlled processes. For example, we may unintentionally fold our arms and lean backwards in an automatic change of body language representing a guarded uncomfortable social reaction. In contrast, body language may also be a controlled process, for example, during a conversation with an individual we are attracted to, we may warmly touch the arm or lean forwards in an attempt to show interest. Consequently, our thoughts and behaviour influence, and are influenced by, our environment and our individual personalities. Social stimuli are dynamic and interactive, in that they may alter as a result of simply being observed.

The term social cognition is relatively new. First used in the 1970’s, with the first journal and textbook entitled ‘Social Cognition’, both published in 1982 (Ostrom, 1984). Since then, the field has dramatically increased with recent work integrating neurobiological and psychological perspectives on social cognition (Adolphs, 2001). Social cognition encompasses many aspects with definitions varying accordingly, thus, at times results in somewhat blurry boundaries. Considered broadly, social cognition involves “the ability to construct representations of the relations between oneself and others, and to use those representations flexibly to guide social behaviour” (Adolphs, 2001, pp 231). In addition, others describe social cognition as the “study of how people process, store, and use the information they process from the social world” (Hamilton, 2005, ppxvii).
Social cognitive information is often personally relevant, context-dependent, complex and variable. Consider the following examples; forming an impression about a friend’s new boyfriend, holding the elevator door for a rushed work colleague, deciding who to vote for in a political election, and lamenting a favourite sporting team’s loss. Each example constitutes social perception, interpretation, integration and storage which influence attitudes and behaviour. Not only is our environment exceptionally rich with social information, the social environment we experience differs considerably between individuals.

The importance of social cognitive skill is clear in day-to-day functioning; for example, it is pivotal to creating and maintaining friendships and the capacity for employment. Furthermore, success in academic, personal and professional settings has been linked to higher levels of ‘emotional intelligence’; a term more recently used to encompass competencies such as self-awareness, self-management, social awareness and relationship management (Goleman, 1998). In addition, empirical evidence has revealed better non-verbal social communication is related to fewer marital complaints (Sabatelli et al., 1986), and interpersonal perception is related to peer-related social skill (Costanzo & Archer, 1989). Furthermore, recognition and differentiation of happy, sad and fearful facial expressions has been associated with social competence in children (Philippot & Feldman, 1990). Aberrant social cognition may impact daily living skills, such as home or financial care, as well as impact on peer, romantic and family relationships. Such compromised social cognitive functioning has been revealed in various psychopathological conditions such as depression (Surguladze et al., 2004), bipolar disorder (Bora et al., 2005), autism (Adolphs et al., 2001), social phobia (Alfano et al., 2008), anxiety (Hofmann, 2007), and schizophrenia (Toomey et al., 1997).

4.1.1 Social Cognition in Schizophrenia

While the neurocognitive impairments in schizophrenia have been widely researched, the impairments in social cognition have only recently begun to receive the same attention (Penn et al., 1997). Many of the core features of schizophrenia have social implications e.g. blunting or inappropriate affect, persecutory or grandiose delusions and hallucinations (Frith, 1992). Schizophrenia patients also exhibit problems with social interaction and interpersonal skills. Further, social competence and activity is related to the rate of relapse for schizophrenia patients (Johnstone et al., 1990). Social cognitive deficits are observable in relatives of schizophrenia patients (Toomey et al., 1999) and in schizotypal personality types (van’t Wout et al., 2004).
Accordingly, social impairments are now considered hallmark characteristics of schizophrenia and are relatively independent of the positive and negative symptoms (Lenzenweger & Dworkin, 1996).

A recent factor analytical study revealed social cognition as one of seven ‘major separable cognitive impairments’ in schizophrenia worthy of inclusion in the National Institute of Mental Health (NIMH) cognitive battery (Measurement and Treatment Research to Improve Cognition in Schizophrenia New Approaches; MATRICS), which was designed for investigations into cognitive intervention in schizophrenia (Nuechterlein et al., 2004). A breakout group arising from the conference surrounding NIMH-MATRICS discussed the importance of social cognition in schizophrenia research with some pertinent recommendations. For example, clear research plans for social cognition research in schizophrenia, including short and long-term human studies, as well as the development of translational animal models of social cognition (Green et al., 2005). Such developments are promising signs for increased awareness of the role of social cognition in schizophrenia. The increasing work on social cognition has led to the amendment of classical cognitive models of schizophrenia; emphasis has shifted from non-social to social cognition which has direct relevance to the symptomatology, aetiology and developmental course of the disorder.

The deficits in social cognitive functioning in schizophrenia have been revealed in both verbal social perception (Ihnen et al., 1998) and non-verbal social perception such as social problem solving, understanding social sequence and social judgement (Toomey et al., 1997). Deficits in performance have also been observed on tests of prosody (Bozikas et al., 2006a), theory of mind (Roncone et al., 2002), social knowledge (Cutting & Murphy, 1990), social bias (Bentall & Kaney, 1989) attribution (Blackwood et al., 2001), and sarcasm (Kosmidis et al., 2008). Further, impairment has been observed on measures of social reasoning, revealing schizophrenia patients tend to attribute negative events to external causes and positive events to internal causes (Silverman & Peterson, 1993). As discussed in section 3.5.3, the deficits in social cognition in schizophrenia are strongly correlated to neurocognition (Vauth et al., 2004), as well as functional outcome (Kee et al., 2003). Brekke et al. (2007) found that baseline neurocognitive and social cognitive performance predicted the level of functional change in schizophrenia patients over the subsequent year.
Despite the strong associations between social cognition and neurocognition, the two are indeed separate constructs (Allen et al., 2007; Penn et al., 1997). Social cognition contributes variance to functional outcome in schizophrenia beyond the variance explained by neurocognition (Brekke et al., 2007; Sergi et al., 2006). Further, research employing structural equation modelling techniques has indicated neurocognition has an indirect relationship with functional status which is mediated by social cognition (Bell et al., 2008; Sergi et al., 2007). For example, findings have suggested that neurocognition affects social cognition and that poorer social cognition leads to social discomfort on the job, which in turn leads to poorer rehabilitation outcomes.

Within the neurocognition literature, there is general consensus about how the different domains of neurocognition are best measured, for example attentional capacity is commonly assessed via CPT and planning by the WCST. An agreement about which tasks are the best examples of each social cognitive domain, has yet to be established (Bell et al., 2008). The majority of reviews agree that clear definitions are necessary for social cognitive research to advance (Couture et al., 2006). The difficulty is, like neurocognition, social cognition is a multifaceted construct encompassing several separable domains (Couture et al., 2006; van Hooren et al., 2008). It is appreciated that most clinical studies cannot include all the different domains of social cognition, however, the components that are investigated must be explicitly and clearly operationalised and the measures used must be well-defined. An additional characteristic of social cognitive research, unlike neurocognition, is that performance is often evaluated based on biases rather than correct or incorrect performance. Consequently, social cognition often focuses on ‘differences in performance’ rather than ‘deficits in performance’. This notwithstanding, research is progressing towards tasks which attempt to generate accuracy scores.

The domains of social cognition under investigation within the schizophrenia literature have included social perception, social knowledge (understanding social situations and rules), attributional style (explanation of the cause of events), theory of mind (inferring content of another person’s mental state) and emotion processing (Green et al., 2005). One social cognitive domain implicated as such a mediator between neurocognition and functional outcome is facial emotion processing (Addington et al., 2006; Vaskinn et al., 2008). The current thesis will focus on facial emotion processing. It needs to be made clear that the author acknowledges that facial emotion processing is only one narrow aspect of the construct, thus conclusions reached from this domain in no way aim to represent the wide-ranging complexities of social cognition in its entirety. This chapter will firstly summarise facial emotion processing in healthy individuals, and
then describe the literature on facial emotion processing in schizophrenia. Thereafter, the methodology used to assess facial emotion processing in the current sample will be described, followed by the performance results. This chapter will conclude with a discussion of these results and their wider implications.

4.2 Background to Facial Emotion Processing

Emotion processing is a broad term and involves a range of domains, including emotional identification, body language, and prosody (Couture et al., 2006). The current chapter will focus on just one aspect of emotion processing, specifically the visual processing of facial emotional content, i.e. how we interpret others’ feelings through their facial expressions.

The ability to recognize and respond to other peoples’ emotions from their facial expression plays a very important role in social functioning, crucial to communication and conveying emotional state (Darwin, 1872). Dealing with visual emotional cues is a complex process involving basic visual perception, scanning, vigilance, and the differentiation of relevant from irrelevant information (Kee et al., 1998a). The face processing model developed by Bruce and Young (1986) is arguably the most influential in summarizing the mechanisms underlying the perception of facial information. This neurocognitive model suggests face processing occurs over several different stages from basic low level perception of sensory information (i.e. recognition of age); to higher level detailed information (i.e. representations relating to identity, name or social connections). Others have extended upon this model by integrating findings from neuroimaging investigations, proposing the different stages of face processing relate to specific cortical substrates (Haxby et al., 2000). These two models will be discussed in greater detail in the following chapter.

While the human face is complex and capable of thousands of different expressions, research on emotion processing has attempted to identify discrete categories of emotion. Despite cultural differences, it is generally agreed that there are several universal emotional categories that can be recognized regardless of ethnicity or background (Ekman et al., 1972; Izard, 1971). These include happiness, sadness, fear, anger, disgust and surprise (Ekman & Oster, 1979). Thus, the majority of emotion processing research has focused on these six basic emotions as well as neutrality, i.e. no emotional expression.
Processing the emotional content of the face has been considered a function of the right hemisphere (Bruyer, 1986; Moscovitch & Olds, 1982; Sackeim et al., 1978). Patients with damage to the right hemisphere of the brain are impaired on emotion identification when compared to healthy controls and patients with damage to the left hemisphere of the brain (Borod et al., 1998). Other research suggests that experience and processing of emotional content is lateralized across the brain (Reuter-Lorenz & Davidson, 1981). The left hemisphere is argued to be responsible for positive or pleasant emotions, for example happiness, whereas the right hemisphere is responsible for all negative or unpleasant emotions, for example sadness, anger, fear. Supporting evidence stems from Wada tests (Lee et al., 1990), behavioural studies (Reuter-Lorenz & Davidson, 1981), and more recently quite compelling evidence from neuroimaging studies (Canli et al., 1998; Lee et al., 2004). Recent neurobiological models indicate emotion perception is represented by multiple systems integrated together whereby different neuroanatomical structures are activated during the presentation of different discrete emotions. Specifically, the amygdala is engaged for fear (Williams et al., 2007b), whereas the subcallosal cingulate is engaged for sadness (Phan et al., 2002). Similarly, the insula and basal ganglia have been consistently implicated in the recognition of disgust (Calder et al., 2001).

Paul Ekman and Wallace Friesen are two researchers who have made a particularly substantial contribution to the understanding of emotion processing from a psychological perspective. These researchers developed the Pictures of Facial Affect (PoFA) which involves black and white photos of eight female and six male individuals each expressing the six basic emotions as well as a neutral expression (Ekman & Friesen, 1976). This stimulus set has been used extensively within the research into emotion processing, thus, much of the literature referred to in this chapter has utilised the PoFA stimuli. The PoFA evolved from earlier work investigating how we discriminate facial behaviour. Ekman and Friesen (1978) developed the Facial Action Coding System (FACS) which was used to investigate patterns of facial muscular movement, which are termed action units (AU). This tool has been used to examine the specific muscle movements involved during the expression of emotion (Gosselin et al., 1997b; Kohler et al., 2004). Investigations using this tool have indicated that expressions of happiness were characterised by cheek raise and lip corner pull, sadness was characterised by eyebrow lower and lip corner depressed and both anger and fear were characterised by eyes wide open, eyebrow lower and mouth open. The greatest overlap in AU was between expressions of anger and sadness, and the least overlap in AU was between fear and happiness (Kohler et al., 2004). Further, emotion recognition accuracy has consistently been shown to be best for expressions of
happiness, followed by sadness, anger and fear. This is not surprising as happy faces showed substantially independent AU characteristics, whereas the negative emotions of sadness, anger and fear all share common AU characteristics. This evidence suggests happy faces are intrinsically easier to identify as they are more easily differentiated from other emotional expressions. This finding provides a problem for research investigating the relative impairment of performance between emotions. This will be discussed in greater detail below.

4.3 Facial Emotion Processing in Schizophrenia

Both Kraepelin (1919) and Bleuler (1911) placed considerable importance on the role of emotion in schizophrenia and outlined its theoretical relevance to key characteristics of the disorder. Current diagnostic tools include numerous references to emotional disturbances in schizophrenia. Patients can suffer from flat affect, oversensitivity to emotion, and anhedonia (i.e. the inability to experience pleasure). The following section will summarise some of the key findings on the investigations into how schizophrenia patients process non-verbal facial emotional content.

Izard (1959) was one of the first to investigate facial emotion processing in schizophrenia, demonstrating that schizophrenia patients could be distinguished from healthy controls based on their incorrect responses to emotional faces. Dougherty et al. (1974) expanded upon this research by including stimuli from multiple emotional categories. More recent literature overwhelmingly indicates that schizophrenia patients do show some level of impairment in decoding emotional content (Archer et al., 1992; Edwards et al., 2002; Feinberg et al., 1986; Kee et al., 2004; Kerr & Neale, 1993; Kohler et al., 2003; Mandal et al., 1998; Morrison et al., 1988) and deficits are observable cross-culturally (Chan et al., 2008; Habel et al., 2000). Impairment in emotion processing is considered specific to the disorder and more severe than deficits observable in other clinical populations such as depression (Gessler et al., 1989), bipolar disorder (Addington & Addington, 1998), borderline personality disorder (Wagner & Linehan, 1999), substance abuse (Bell et al., 1997), anxious neurosis (Mandal & Rai, 1987), and Parkinson’s Disease patients, however, to a similar degree as right-hemisphere brain-damaged patients (Borod et al., 1989; Borod et al., 1993).
4.3.1 Emotion Processing and Stage of Illness

Although deficits in facial emotion processing are observable over different stages of the disorder, i.e. child, adolescent and adult patients (Walker et al., 1980), there appears some association with chronicity of illness. While most researchers agree that chronic patients show deficits in performance (Kerr & Neale, 1993; Mueser et al., 1996), some have indicated performance is intact for acutely psychotic patients (Bellack et al., 1996; Mueser et al., 1997). In comparison, others have indicated the performance deficit is actually greater for acute patients than chronic patients (Cutting, 1981; Gessler et al., 1989; Penn et al., 2000) suggesting that impairment is exacerbated during the acute phase, however, still apparent in remission. Performance deficits are observable in patients presenting with first-episode psychosis (Addington et al., 2006; Edwards et al., 2001), indicating that emotion processing impairment does not develop with chronicity, rather is observable early on in the illness course. Although the current study will not examine emotion processing performance in first episode patients, an examination of the association with duration of illness will be conducted.

4.3.2 Emotion Processing in At-Risk Populations

Subtle deficits in emotion processing are also observable in populations at risk for schizophrenia (for a review see Phillips & Seidman, 2008). Some studies have revealed deficits in facial emotion perception in the unaffected biological siblings of schizophrenia patients when compared on multiple emotion processing measures (Kee et al., 2004). Others have indicated that basic emotion identification tasks may not be sensitive enough to reveal subtle impairments in performance (Toomey et al., 1999).

Other individuals considered at risk for schizophrenia include those characterised with schizotypal personality traits. Some researchers have demonstrated performance by schizotypal individuals does not differ to healthy controls, however, do cite potential psychometric limitations of the tasks used including ceiling effects (Toomey & Schuldberg, 1995). Others have indicated schizotypal individuals show specific deficits for positive emotions (Waldeck & Miller, 2000). In contrast, Williams et al. (2007a) indicated reduced accuracy for negative emotions in individual characteristic of the negative schizotypal dimension. An emotion processing deficit in schizotypal individuals therefore, with present data, appears dependent on symptom subtype and emotion valence. The combined research on individuals at risk for schizophrenia indicates that
impairment in emotion processing may assist as a vulnerability marker, and potentially flag a predisposition to the disorder.

4.3.3 Associations between Emotion Processing and Clinical Characteristics

There is evidence to suggest a differential impairment for the subtypes of schizophrenia. Patients displaying characteristics of the non-paranoid subtype tend to show greater deficits in emotion processing compared to paranoid patients (Chan et al., 2008; Kline et al., 1992; Lewis & Garver, 1995). Kline et al. interpret these results in terms of the differences in cognitive schema between non-paranoid and paranoid schizophrenia patients. Non-paranoid patients typically display more poorly organised cognitive schema, in comparison paranoid patients have strong emotional representations, particularly for negative information. Results from other similar methods of sub-typing schizophrenia indicate that ‘deficit syndrome’ patients, who show predominantly negative symptoms, exhibit greater impairment in emotion perception compared to patients from the ‘non-deficit’ subtype (Bryson et al., 1998).

Findings on the relationship between symptomatology and emotion processing in schizophrenia are somewhat inconsistent. Some indicate no relationship between emotion processing and symptomatology (Cramer et al., 1989; Kucharska-Pietura et al., 2005); others indicate deficits are associated with both negative and positive symptomatology (Kohler et al., 2000). Some show associations with increased positive symptoms (Hall et al., 2004; Poole et al., 2000; Weniger et al., 2004) and others with negative symptoms (Mandal et al., 1999). Specifically, impaired emotion processing has been associated with alogia (Gaebel & Wolwer, 1992) and flat affect (Gur et al., 2006). There is also some evidence to suggest the association between negative symptomatology and impaired emotion processing exists only for recognition of fearful faces and not for angry or happy faces (van't Wout et al., 2007). Johnston et al. (2008b) indicated a possible double dissociation whereby positive symptoms related to poor performance for dynamic depictions of facial emotion whereas negative symptoms severity related to poor performance for static depictions. Although these results are variable, the literature on emotion processing generally supports a stronger link to negative over positive symptoms, which is thus the premise behind predictions of the current body of work.

Discordantly, other researchers have found emotion processing deficits are unrelated to clinical characteristics and psychopathology (Lewis & Garver, 1995; Salem et al., 1996; Silver & Shlomo,
2001; Wolwer et al., 1996). Further, Addington and Addington (1998) revealed no improvement in facial emotion processing despite significant improvement in PANSS ratings. Consequently, researchers have concluded that deficits in emotion processing appear to be trait-related rather than state-related and do not improve concurrently with symptomatology. It is therefore an aim of the current body of work to investigate these inconsistencies regarding the relationship between emotion processing and clinical characteristics.

Emotion processing deficits are observable in both medicated (Salem et al., 1996) and unmedicated (Kerr & Neale, 1993) schizophrenia patients. Impairment appears unrelated to medication (Wolwer et al., 1996), with some researchers demonstrating little improvement in performance on emotion processing tasks after treatment with typical antipsychotic medication (Lewis & Garver, 1995), however, others have shown improvement after treatment with more recently developed 2nd generation atypical antipsychotic medication (Kee et al., 1998b). The patients from the current work were medicated; investigations will be made into the associations between emotion processing and antipsychotic medication.

4.3.4 Emotion Processing and Neurocognition

As discussed at the end of Chapter 3, emotion processing has been shown to be associated with other neurocognitive abilities, particularly in the schizophrenia literature. Findings have indicated that schizophrenia patients who exhibit impaired emotion processing also show performance deficits on tasks of mental flexibility, attention, memory, and language (Addington & Addington, 1998; Bryson et al., 1997; Gur et al., 2006; Kohler et al., 2000; Sachs et al., 2004). This association will be discussed in greater detail in Chapter 6.

4.3.5 Emotion Processing and Functional Outcome

There are clear associations between emotion processing and functional outcome for schizophrenia patients. As discussed above, emotion processing specifically has been implicated as a mediating factor in the relationship between neurocognition and functional outcome (Addington et al., 2006; Green et al., 2000; Vaskinn et al., 2008). Kee et al. (2003) revealed that emotion processing was a key predictor for work functioning and independent living for schizophrenia patients at baseline and at 12-month follow-up. Similarly, Hooker and Park (2002) demonstrated correlations between facial emotion recognition and communication and
occupation dysfunction. Further, facial emotion processing has been related to behaviour on the hospital ward, with task performance showing associations with degree of social interaction, personal appearance, hygiene (Mueser et al., 1996) and neatness (Penn et al., 1996). Additionally, emotion identification has been associated with higher social skill and involvement in conversation, and in particular greater speech clarity (Ihnen et al., 1998). Poole et al. (2000) found that even after controlling for general cognitive functioning and symptomatology, impaired emotion processing was associated with poor interpersonal relationships and bizarre behaviour involving sociosexual interactions, clothing and appearance. This thesis does not claim to investigate functional outcome in as much detail as some of the studies discussed above, however, the relationship between emotion processing and a global assessment of functioning will be examined.

4.3.6 Assessment Methods of Emotion Processing in Schizophrenia

The methods used to assess emotion processing in schizophrenia vary greatly. According to a recent review (Couture et al., 2006), the two the most commonly used tools are the Facial Emotion Identification Test (FEIT) and Facial Emotion Discrimination Test (FEDT) developed by Kerr and Neale (1993). Other studies, as with the current work, have created tailored tasks using stimuli sets such as the PoFA (Ekman & Friesen, 1976). This has permitted a more detailed analysis of the different emotional categories.

The emotion processing literature is confounded by several variations in study design and sample differences. For example, stimulus characteristics range greatly in terms of the number of emotional categories used, i.e. anger, happiness, fear, as well as emotional valence, i.e. happiness vs. unhappiness (Levy et al., 1960), favourable vs. unfavourable (Izard, 1959) or friendliness (Cutting, 1981). The majority of studies have used static photographic images, although there are several exceptions that have used dynamic images (Archer et al., 1994; Tomlinson et al., 2006) and videos (Cramer et al., 1989; Hellewell et al., 1994; Joseph et al., 1992; Muzekari & Bates, 1977). Further, posed images are more common than spontaneous images.

Another varying design factor between studies involves a difference in response type. Different task designs have ranged from emotion recognition (Kohler et al., 2000), matching (Martin et al., 2005), labelling and discrimination (Gur et al., 2006; Heimberg et al., 1992; Walker et al., 1984), which may necessitate forced choice or open ended responses. The open ended responses are
arguably more ecologically valid, but the forced choice tasks permit more easily quantifiable responses. Clearly the more response options a participant has on offer, the more complex and potentially difficult the task becomes. Therefore, studies have aimed to keep tasks simple yet difficult enough to avoid floor and ceiling effects and maintain motivation. Similarly, the stimulus presentation time has also varied from very short presentations, i.e. 500ms (Herrmann et al., 2006), to longer presentations, i.e. 10 seconds (Kucharska-Pietura et al., 2005), 15 seconds (Kerr & Neale, 1993), as well as unlimited free viewing (Kohler et al., 2000). Again, care must be taken during task design as not to overburden participants, particularly schizophrenia patients who, as discussed in the previous chapter, can exhibit a generalised slowing of information processing.

Healthy emotion processing relies greatly on the information provided in the eyes (Baron-Cohen et al., 1997a). Although some have indicated a developmental trend whereby as children age they look more to the mouth region for emotion cues and more to the eyes for identity (Karayanidis et al., 2009). A limited number of studies have compared the difference in emotion processing in schizophrenia when the whole face is available for processing compared to restricted information such as presentation of the eye-region alone. Interestingly, Mandal and Palchoudhury (1989) found that recognition of different emotional expressions was best predicted by different facial areas, and that although schizophrenia patients showed a significant deficit in identifying emotion when presented with the whole face, they did not differ in expression identification from controls or anxiety neurotic patients when presented with part faces. This is a critical finding as it suggests that performance was disrupted with an increase in facial information. Where the control participants benefited from this extra information and performance was better for the whole face compared to the eyes only, the schizophrenia patients did not benefit as much. Consequently they showed similar performance when facial information was limited i.e. part face, yet differed in performance when the whole face was presented. In comparison, Kington et al. (2000) revealed that schizophrenia patients showed impaired recognition of complex states when the eyes were presented alone. It must be noted, however, that Kingston et al. involved a two-choice forced choice design and that future studies should make a more thorough examination of differences in emotion processing using labelling and discrimination paradigms with increased response options. Considering the limited literature and conflicting findings in this ‘face versus part’ emotion processing research, this is of particular interest for the current body of work.
4.3.7 **Generalized or Emotion Specific Deficit?**

Patients with schizophrenia show impaired performance on a wide variety of emotion processing tasks; however, some researchers have argued performance deficits are not generalised to all emotional content. Schizophrenia patients have shown particular impairment for disgusted and neutral faces (Kohler et al., 2003) as well as fearful (Archer et al., 1994), angry (Bediou et al., 2005; Mandal et al., 1998), and sad facial expressions (Schneider et al., 1995). In contrast, patients have shown comparable performance to healthy controls for happy faces (Burch, 1995). Consequently, researchers have argued for the ‘emotion-specific deficit hypothesis’, postulating that schizophrenia patients show impairment in some but not all emotional expressions. Specifically, performance remains relatively intact for positive emotional expressions, such as happiness and surprise, however deteriorates for facial information of negative valence. A social-cognitive perspective on this hypothesis argues that positive facial expressions are more communicative and negative facial expressions are more emotion-laden; schizophrenia patients show a reduction in sensitivity to emotional content, and thus, show particular deficits on negative emotional content (Mandal et al., 1998). A neurobiological perspective in contrast, argues that schizophrenia patients show particular abnormalities in cortical regions specific to negative emotion i.e. limbic regions, which consequently results in impaired performance (Gur et al., 2002).

Those researchers who favour the emotion-specific hypothesis (Borod et al., 1993; Bryson et al., 1997; Penn et al., 2000; Penn et al., 1997; Silver et al., 2002) argue that performance deficits arise from impaired information processing specific to the emotional content of the face and not information from the non-emotional content. In comparison, other researchers argue for the ‘generalized emotion deficit hypothesis’, positing that the emotion processing impairment seen in schizophrenia patients is a result of a general perceptual deficit for understanding facial information (Johnston et al., 2001; Mueser et al., 1997; Salem et al., 1996; Silver & Shlomo, 2001). This viewpoint suggests the specific impairment for negative emotions is merely a reflection of the difficulty level of positive vs. negative emotional content. Intact performance for positive emotional content has been reflected by potential ceiling effects (Kline et al., 1992). From the basic universal emotions generally used in emotion processing research, there are more emotions weighted with a negative valence than positive valence. For example, anger, fear, sadness, and disgust are considered negative, whereas, happiness is the only truly positive emotion (surprise can also be considered positive at times depending on the triggering context).
As indicated above, there is considerable overlap in the muscular behaviour of the face between negative emotions of sadness, anger, fear, and disgust potentially making these emotions harder to differentiate between. The distinct lack of overlap between happy faces with other emotions as well as the unique features happy faces possess (i.e. upturned mouth) leaves them inherently easier to identify and recognise.

The notion that some emotional categories are easier to identify than others has been investigated in healthy control participants. Johnston et al. (2003) degraded facial images to test for differential performance across emotional category. Faces displaying happiness, surprise, fear, disgust, anger, sadness and no emotion were altered by applying a pixilation filter to decrease the stimulus resolution, and thus increase the difficulty for recognition. The results indicated that the performance deterioration was indeed differential over emotional category. Those emotional categories with a negative valence were subject to the greatest drop in performance whereas performance for the positive emotions showed less deterioration. The researchers concluded that the psychometric characteristics of different emotional categories may be responsible for the specific deficits shown by schizophrenia patients to negative valence faces. They, therefore, argued against the ‘emotion-specific deficit’ hypothesis, and showed comparable performance between schizophrenia patients and healthy controls who responded to degraded stimuli (Johnston et al., 2006).

According to the generalised emotion deficit hypothesis, the performance deficits on facial emotion processing tasks are resultant of impaired processing of general facial information. Studies have investigated the performance of schizophrenia patients using a differential deficit design including tasks requiring emotional and non-emotional face processing (Archer et al., 1992; Kerr & Neale, 1993; Salem et al., 1996). Results have indicated schizophrenia patients showed deficits on tasks requiring recognition of emotion as well as identity and unfamiliar face matching, thus demonstrating a generalised performance deficit not only a deficit for emotion processing. Other approaches using a differential design included tasks of face recognition and facial emotion recognition that were psychometrically well matched on reliability and discriminatory power (Novic et al., 1984). Results indicated schizophrenia patients showed impaired emotion processing compared to controls, however when performance on the face processing control task was included as a covariate, the group difference no longer existed.
Support for the emotion-specific deficit hypothesis is inconsistent with regard to which emotional categories are particularly impaired in schizophrenia. As noted, some have indicated differential impairment in expressions of fear and disgust (Kohler et al., 2003), whereas others have suggested anger and sadness (Bediou et al., 2005). Therefore, considering these contradictory results, and the difference in difficulty reflected by healthy control performance, the current author favours the generalised over emotion-specific deficit hypotheses for schizophrenia patients.

4.3.8 Limitations of Previous Literature

Despite a general agreement that impairment in emotion processing is evident in schizophrenia, the specific findings are inconsistent over several issues. Although a large volume of research investigating emotion processing in schizophrenia exists, there is a great deal of inter-study variability and some notable limitations. While it is understandable that some of these limitations are difficult to avoid, the current study aims to identify and address some of these issues.

With regards to participant sample, some studies have included groups of relatively small sample size. Furthermore, numerous studies have included inappropriate control groups such as university students or hospital staff. Using such groups to compare performance does not provide a demographically appropriate comparison due to extreme differences in background, education and age, such differences may thus skew results. For the schizophrenia samples, early work included a distinct lack of specific diagnostic criteria (Levy et al., 1960). Furthermore, some studies have provided limited information on length of illness and level of current symptomatology (Archer et al., 1992; Gessler et al., 1989), making it difficult to draw conclusions about the time course of impairment and how this may relate to a current or remitted psychotic state. Others make conclusions based on the performance of only inpatients, when in actual fact most individuals with schizophrenia are outpatients. Several studies include schizoaffective patients in the same group as the schizophrenia patients without accounting for the differential effects mood may play on performance.

There are some important procedural characteristics that need to be paid attention to. Some emotion processing tasks have failed to include practice items to ensure participants understand and are able to perform the task. Furthermore, there is substantial variability in the stimuli characteristics, presentation time and task design across studies. Therefore, the current work
aims to use the same stimulus set of facial photographic images under different task design, each of which include sufficient practice trials.

4.4 Aims & Hypotheses

After the preceding literature review, several empirical aims were developed:

A. To assess the discrimination and labelling of facial emotional expression in schizophrenia patients and compare performance to that of a healthy control participants.

B. To assess emotion discrimination and labelling upon viewing the whole face compared to the eye region alone.

C. To assess performance across different emotional expressions including happiness, sadness, fear, anger and no emotion, to provide evidence for the generalised deficit hypothesis as opposed to the specific deficit hypothesis (Emotion Labelling Task only).

D. To investigate the relationships between emotion processing and demographic variables (pre-morbid IQ, education, gender and age) as well as psychopathological variables (medication, PANSS ratings, GAF, age at illness onset and duration of illness).

It was also an intention of the current work to provide appropriate practice trials on tasks unfamiliar to participants and to assess both accuracy (% correct) and response time (ms).

It was hypothesised that healthy controls will make fewer errors and respond significantly faster than schizophrenia patients on both emotion discrimination and labelling tasks. It was expected that overall performance of both groups would be better when presented with the whole face compared to the eyes only, however, this difference may be greater for healthy controls i.e. controls would benefit more from an increase in facial information. Further, due to an overall different in difficulty across the emotional expressions, performance would be better for expressions of happiness compared to facial emotional expressions with a negative valence. This would be apparent for all participants. It was further predicted performance of the schizophrenia group may be associated with negative symptomatology (i.e. PANSS negative score).
4.5 Task Methodology

The two following tasks were administered to the two participant groups detailed in Chapter Two. These tasks were used to assess discrimination and identification of facial emotional information. Two stimuli types were used for each task, the whole face as well as the eyes only. The stimuli were greyscale photographic images selected from the commonly used Ekman and Friesen series, PoFA (1976). The stimuli involved ten faces (five male, five female) each displaying the emotional expressions: happiness, sadness, anger, fear and neutrality (no emotion). Thus, for each task there were 50 different stimuli which were the same for both tasks. Photoshop image editing software was used to crop these stimuli to appropriate size. These facial images included no facial hair, jewellery, make-up, or glasses and were cropped to exclude any head hair. The stimuli for the whole face condition consisted of an oval shape, 220 x 300 pixels, spanning the top of the forehead to the bottom of the chin, excluding the ears either side. The stimuli for the eyes only condition consisted of a rectangle shape, 220 x 76 pixels, spanning the eyes, eyebrows and bridge of the nose only. All images were presented on a white background. Five additional stimuli were selected as practice stimuli. Participants were given instructions and five practice trials prior to each task beginning.

Stimuli were selected based on the level of consistent agreement on the emotion expression outlined by Ekman and Friesen (1976). Although the emotional expressions of surprise and disgust are considered two of the ‘universal emotions’, they were not included in the present study. In line with previous work, surprise was not considered a suitable inclusion as the valence varies dramatically depending on the triggering source, pleasant or unpleasant. Disgust was not included as some authors consider it a composite representation of the other universal emotions (Kohler et al., 2004).

4.5.1 Facial Emotion Discrimination Task

This task involved two stimuli types; a ‘whole face’ condition and an ‘eyes only’ condition. Participants were presented with two faces (or two sets of eyes) on the screen each displaying one of the five emotional expressions detailed above. They were required to determine whether each pair of faces (or eyes) showed the same or different emotion, via a two-button press. A piece of paper was placed in front of the participant to remind them which button was which. The task involved 50 randomised trials in total, involving 25 same and 25 different pairings.
Each pair was presented for 2000ms, followed by a fixation cross for 1500ms. This task took participants approximately three minutes to complete each condition.

4.5.2 **Facial Emotion Labelling Task**

The labelling task also involved two stimuli types; a ‘whole face’ condition and an ‘eyes only’ condition. Participants were presented with a single face (or a single pair of eyes) on the screen that displayed the expression of happiness, sadness, anger, fear or neutrality. They were required to determine which of the five emotions the face (or eyes) was showing, indicating their response via a 5-button press. A piece of paper was placed in front of the participant to remind them which button was which. The task involved 50 randomised trials in total, involving ten presentations for each of the five emotions. Each face (or pair of eyes) was presented for 2000ms, followed by a fixation cross for 1500ms. This task took participants approximately three minutes to complete each condition.

The dependent variables to be examined for both tasks were mean response time to correct responses (ms) and accuracy (% correct).

4.6 **Results**

A mixed-design ANOVA was conducted to compare the performance of schizophrenia patients and controls on the eyes only and whole face conditions of the emotion discrimination and labelling tasks. Analysis was completed on both accuracy and response time data. Preliminary data analyses were conducted to ensure there was no violation of the assumptions of normality, homogeneity of variance, and homogeneity of intercorrelations. There was an issue of homogeneity of variance on several measures (emotion discrimination whole condition accuracy, emotion labelling eyes condition accuracy happy and fear, emotion labelling whole condition accuracy happy, neutral, anger and fear) indicating the variance for the two participant groups was not equal on these variables. However, considering the groups were equal in size, ANOVA is robust to violations of this assumption. There were no apparent floor effects for either task, nor were there any ceiling effects for the emotion discrimination task. For the emotion labelling task however, healthy control participants performed at ceiling when presented with whole faces displaying a happy emotional expression. One schizophrenia patient did not complete the emotion labelling task.
4.6.1 Facial Emotion Discrimination

Accuracy and response times for schizophrenia patients and healthy controls on the facial emotion discrimination task are presented in Table 10. Initial data analysis was conducted to explore any bias between responses of ‘same’ or ‘different’ for either participant group. The results indicated no differences between same or different response variables for either accuracy \(F(1,56)=.37, p>.05\) or response time \(F(1,56)=.07, p>.05\). Nor were there any difference between the groups for accuracy \(F(1,56)=.23, p>.05\) or response time \(F(1,56)=1.14, p>.05\). Therefore, the same and different variables were collapsed creating average variables for each condition (whole and eyes).

Accuracy
A. Group differences: There was a main effect of group; overall control participants performed more accurately \(M=82.03\) than schizophrenia patients \(M=67.38\%\) \(F(1,56)=46.68, p<0.001\).

B. Eyes vs. whole face: Further, there was a main effect of condition; all participants were more accurate when presented with the whole face \(M=78.38\%\) than with the eyes only \(M=71.03\%\) \(F(1,56)=44.43, p<0.001\). This pattern of performance was similar for both schizophrenia patients and healthy controls as there was no significant group by condition interaction.

Table 10. Performance of Schizophrenia Patients & Control Participants on the Facial Emotion Discrimination Task

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia ((n=29))</th>
<th>Controls ((n=29))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy (% correct)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole face</td>
<td>70.62 (10.86)</td>
<td>86.14 (6.59)</td>
</tr>
<tr>
<td>Eyes only</td>
<td>64.14 (9.98)</td>
<td>77.93 (8.73)</td>
</tr>
<tr>
<td>Response Time (ms)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole face</td>
<td>1564.13 (249.80)</td>
<td>1543.85 (257.97)</td>
</tr>
<tr>
<td>Eyes only</td>
<td>1519.43 (325.12)</td>
<td>1578.68 (253.52)</td>
</tr>
</tbody>
</table>

Response Time
Analysis of the response time data indicated no overall difference in response time between healthy control participants and schizophrenia patients. Further, there was no significant difference in response time for participants when they were presented with the whole face compared to the eyes only. Interestingly, there was a trend toward a group x condition interaction, suggesting that schizophrenia patients and healthy controls exhibit a different pattern of response time for the two conditions \(F(1,56)=3.44, p=0.069\). As indicated in Figure 4, the
control participants tended to respond faster when the whole face was presented than when the eyes only were presented. In comparison, the schizophrenia patients tended to respond faster to the eyes only than the whole face. Post-hoc paired-samples t-tests confirmed these differences were not statistically significant.

![Response Times for Schizophrenia Patients and Control Participants on Facial Emotion Discrimination of Whole Faces vs. Eyes Only](image)

**Figure 4.** Response Times for Schizophrenia Patients and Control Participants on Facial Emotion Discrimination of Whole Faces vs. Eyes Only

D. Correlations with demographics and clinical variables: Pearson product moment correlation coefficients were used to investigate associations between emotion discrimination and demographic variables (Bonferroni corrected $p<0.017$) and clinical characteristics (Bonferroni corrected $p<0.006$). Analysis indicated no significant relationship between facial emotion discrimination and age in the schizophrenia group, however, the healthy control groups accuracy performance was correlated with the whole face condition ($r=-0.47$). There were no associations between emotion discrimination and years of education or predicted IQ for either participant group. Likewise, there were no significant effects of gender on emotion discrimination for either group, nor were there any gender by group interactions, indicating males and females from the two different groups performed similarly. For the schizophrenia patients, no significant associations were observed between emotion discrimination and clinical characteristics such as medication, age at illness onset, illness duration, GAF or PANSS scores.
Facial Emotion Labelling

A. Group differences: Accuracy and response times for schizophrenia patients and healthy controls on the facial emotion labelling task are presented in Table 11. Overall there was a main effect of group, with the control participants performing more accurately (\(M=84.62\%\)) than schizophrenia patients (\(M=69.96\%\)) (\(F(1,55)=31.90, p<0.001\)).

B. Eyes vs. whole face: Participants were more accurate when presented with the whole face (\(M=81.80\%\)) than when they viewed the eyes only (\(M=72.79\%\)) as indicated by a main effect of condition (\(F(1,55)=87.50, p<0.001\)). This pattern was the same for both schizophrenia patients and healthy controls, as there was no significant group by condition interaction.

C. Performance across different emotions:

Accuracy

Overall, there was a main effect of emotion (\(F(4,52)=40.56, p<0.001\)); participants were most accurate for happy expressions (\(M=97.71\%\)) followed by neutral (\(M=79.62\%\)), fear (\(M=75.60\%\)), anger (\(M=72.96\%\)) and were least accurate for sad expressions (\(M=66.58\%\)). Furthermore, there was a significant interaction between emotional expression and group (\(F(4,52)=3.16, p<0.05\)). Post-hoc independent samples t-tests (Bonferroni correction \(p<0.01\)) were conducted to investigate this interaction. Analysis indicated that the two groups differed in performance for the sad (\(t(55)=5.06, p<0.001\)), neutral (\(t(46)=3.19, p<0.01\)), angry (\(t(44)=3.29, p<0.01\)) and fearful (\(t(42)=4.45, p<0.001\)) emotions, however, not for the happy emotion, with the schizophrenia group performing the worst on all emotional expressions.

A significant interaction between condition and emotion was also revealed (\(F(4,52)=4.23, p<0.01\)). Post-hoc paired samples t-tests (Bonferroni corrected \(p<0.01\)) revealed overall participants were more accurate for whole faces than eyes only, however, only for happy (\(t(56)=-10.38, p<0.001\)) and angry (\(t(56)=-5.54, p<0.001\)) facial expressions. There was no three-way interaction between group, condition and emotion. However, such an interaction may have been concealed due to the ceiling effects observable for expressions of happiness. Therefore, exploratory analysis was performed to investigate whether the effect of condition on emotion was different for schizophrenia and healthy controls. Separate repeated measures ANOVAs were completed for each group over each emotion. Results indicated that schizophrenia patients
performed better on whole faces compared to eyes only for the emotional expressions of happiness \((F(1,27)=45.97, p<0.001)\) and anger \((F(1,27)=8.82, p<0.01)\). In comparison, healthy controls performed better on whole faces compared to eyes only for all the emotional expressions happy \((F(1,28)=92.49, p<0.001)\), sad \((F(1,28)=6.10, p<0.05)\), anger \((F(1,28)=31.92, p<0.001)\) and fear \((F(1,28)=6.68, p<0.05)\) and only not significant for neutral.

Table 11. Performance of Schizophrenia Patients & Control Participants on the Facial Emotion Labelling Task

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Condition</th>
<th>Schizophrenia ((n=28))</th>
<th>Controls ((n=29))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accuracy (% correct)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Happy</td>
<td>Whole face</td>
<td>96.43 (13.39)</td>
<td>100.00 (0.0)</td>
</tr>
<tr>
<td></td>
<td>Eyes only</td>
<td>81.43 (19.00)</td>
<td>88.97 (6.18)</td>
</tr>
<tr>
<td>Sad</td>
<td>Whole face</td>
<td>58.57 (17.79)</td>
<td>80.00 (20.87)</td>
</tr>
<tr>
<td></td>
<td>Eyes only</td>
<td>55.00 (17.32)</td>
<td>72.76 (17.50)</td>
</tr>
<tr>
<td>Neutral</td>
<td>Whole face</td>
<td>77.14 (18.83)</td>
<td>88.62 (12.46)</td>
</tr>
<tr>
<td></td>
<td>Eyes only</td>
<td>68.57 (25.78)</td>
<td>84.14 (15.93)</td>
</tr>
<tr>
<td>Anger</td>
<td>Whole face</td>
<td>73.57 (23.76)</td>
<td>87.59 (11.23)</td>
</tr>
<tr>
<td></td>
<td>Eyes only</td>
<td>59.29 (20.35)</td>
<td>71.38 (15.05)</td>
</tr>
<tr>
<td>Fear</td>
<td>Whole face</td>
<td>66.07 (23.93)</td>
<td>90.00 (11.34)</td>
</tr>
<tr>
<td></td>
<td>Eyes only</td>
<td>63.57 (27.52)</td>
<td>82.76 (17.09)</td>
</tr>
<tr>
<td></td>
<td>Response Time (ms)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Happy</td>
<td>Whole face</td>
<td>1152.13 (234.31)</td>
<td>1053.97 (174.16)</td>
</tr>
<tr>
<td></td>
<td>Eyes only</td>
<td>1352.14 (255.94)</td>
<td>1175.46 (223.74)</td>
</tr>
<tr>
<td>Sad</td>
<td>Whole face</td>
<td>1627.03 (271.21)</td>
<td>1495.40 (408.15)</td>
</tr>
<tr>
<td></td>
<td>Eyes only</td>
<td>1553.61 (280.95)</td>
<td>1507.29 (317.52)</td>
</tr>
<tr>
<td>Neutral</td>
<td>Whole face</td>
<td>1574.60 (344.75)</td>
<td>1388.44 (261.38)</td>
</tr>
<tr>
<td></td>
<td>Eyes only</td>
<td>1508.69 (281.18)</td>
<td>1461.97 (258.40)</td>
</tr>
<tr>
<td>Anger</td>
<td>Whole face</td>
<td>1548.80 (291.81)</td>
<td>1557.93 (271.96)</td>
</tr>
<tr>
<td></td>
<td>Eyes only</td>
<td>1559.63 (299.10)</td>
<td>1556.17 (276.94)</td>
</tr>
<tr>
<td>Fear</td>
<td>Whole face</td>
<td>1700.70 (317.36)</td>
<td>1559.93 (287.69)</td>
</tr>
<tr>
<td></td>
<td>Eyes only</td>
<td>1620.54 (350.24)</td>
<td>1495.20 (289.01)</td>
</tr>
</tbody>
</table>

Response Time

Analysis of the response time data indicated no overall difference in response time between healthy control participants and schizophrenia patients. There was no significant difference in response time for whole face compared to the eyes only. This was the case for both groups as indicated by no significant interaction between group and condition. Similar to the accuracy data, overall, participants responded faster to emotional expressions of happiness \(\bar{M}=1183.43\), followed by neutral \(\bar{M}=1483.43\), with similar response times for sad \(\bar{M}=1545.83\), anger \(\bar{M}=1555.63\) and then fear \(\bar{M}=1594.09\) \((F(4,50)=105.81, p<0.001)\). A lack of interaction between group and emotion indicated this pattern of response time was similar for the two groups. Analysis revealed a significant interaction between condition and emotion.
Post-hoc paired samples t-tests (Bonferroni corrected \(p<0.01\)) revealed overall participants were only faster to respond to whole faces than eyes only for happy facial expressions (\(t(56)=5.88, p<0.001\)).

Lastly, the three-way interaction between group, condition and emotion was significant (\(F(4,50)=2.55, p=0.05\)), thus suggesting the effect of condition on emotion was different for schizophrenia and healthy controls. As with the accuracy data, separate repeated measures ANOVAs were completed for each group over each emotion. Results indicated that responses for whole faces compared to eyes only were significantly faster only for the emotional expressions of happiness for healthy controls (\(F(1,28)=24.09, p<0.001\)) and schizophrenia patients (\(F(1,26)=16.12, p<0.001\)). Furthermore, with respect to the group differences, although paired-samples post-hoc tests revealed that the only significant differences between conditions for both groups lay with the happy expressions; the groups showed a slightly different pattern of performance for other expressions. With the exception of happy expressions, control participants demonstrated similar response times between the whole face verses eyes only condition; responses to sad and neutral expressions were slightly quicker for the whole condition and responses to anger and fear slightly quicker for the eyes condition. In comparison, with the exception of happy expressions, schizophrenia patients demonstrated consistently quicker response times for the eyes only condition for all other emotions.

D. Correlations with demographics and clinical variables: Spearman’s rank order correlation coefficients were used to investigate associations between emotion labelling and demographic variables (Bonferroni corrected \(p<0.017\)) and clinical characteristics (Bonferroni corrected \(p<0.006\)). Analysis indicated associations between facial emotion labelling and age only for control participants and only for expressions of anger when viewing the eyes only (\(r=-.61\)) and expressions of sadness when viewing the whole face (\(r=-.62\)). Further, there were no significant associations between emotion labelling and years of education or predicted IQ for either participant group. Likewise, there were no significant effects of gender on emotion labelling for either group, nor were there any gender by group interactions, indicating males and females from the two different groups performed similarly. For the schizophrenia patients, no significant associations were observed between emotion labelling and clinical characteristics such as medication, age at illness onset, illness duration, GAF or PANSS scores.
4.6.3 Between-Task Correlations

To assess the correlations between tasks, overall accuracy scores and response times were computed for both the discrimination and labelling tasks. Accuracy scores for the two tasks were significantly correlated for both healthy controls ($r=.55$, $p<0.005$) and schizophrenia patients ($r=.42$, $p<0.05$). Likewise response times for the two tasks were significantly correlated for both healthy controls ($r=.76$, $p<0.001$) and schizophrenia patients ($r=.72$, $p<0.001$). This indicates the two tasks were assessing the same underlying construct of facial emotion processing.

4.7 Discussion

Healthy controls and schizophrenia patients completed two emotion processing tasks. The addition of practice trials ensured participants understood the task and what was required of them. Consistent with previous investigations, schizophrenia patients revealed impaired emotion processing. For both the discrimination and labelling of facial emotional information, schizophrenia patients showed significantly lower accuracy rates compared to healthy control participants. There were however, no overall differences in response time between the two groups. This is encouraging as it suggests there was no speed-accuracy trade-off, and therefore any deficits are the result of perceptual differences rather than a generalised motor slowing. Accuracy rates were slightly higher for the emotion labelling task compared to the discrimination task for both groups, this is consistent with previous work utilising both types of task design (Addington et al., 2006; Penn et al., 2000). Thus, schizophrenia patients do not appear to be differentially impaired for either the labelling or discrimination task conditions, with both task designs revealing performance deficits. This is consistent with the previous literature that has demonstrated impairments are present over different response formats and task design (Edwards et al., 2002).

As expected, on the labelling task schizophrenia patients and healthy control participants were more accurate when responding to whole faces than eyes only, there were however no differences in response time between the conditions. This indicates that accuracy increases when more information from the face is available, however response time does not quicken.
For the discrimination task, there was again greater accuracy responding to the whole face than the eyes in all participants, however it was also revealed a trend for controls to respond faster for the whole face condition than the eyes only condition. When a whole face is presented (as opposed to the eyes only) the extra information available includes other features such as the mouth, however perhaps more importantly, configural information is also present. Configural information involves the subtle spacing between features such as distances between the eyes and mouth etc. The relationship between the features has been shown to be crucial in allowing accurate emotion perception. For example, key AUs involve the lowered eyebrow, this is known to represent sadness (Ekman & Friesen, 1978). This lowered eyebrow is better observed in relation to the rest of the face. The configural information detailing this relationship aids in an overall representation of the face. Using this configural information to one’s advantage and forming an overall representation results in a more efficient processing strategy than combining information from the multiple features and separately adding this information together in a piecemeal fashion. Thus, whole-face perception typically involves more efficient configural processing which in this study was reflected by the accuracy and response time performance of the healthy control participants on the emotion discrimination task. The schizophrenia patients in comparison are predicted not to show efficient processing strategies. Although their accuracy performance for emotion discrimination was not compromised for whole faces compared to eyes only, their response time did deteriorate. The schizophrenia patients responded to the whole face slower than the eyes only despite the fact that extra information was available to aid performance. It appears the patients may have utilised the more time-consuming strategy of processing each piece of featural information the whole face offered separately, rather than integrating this information into an overall representation. The current task provided participants with adequate time to respond, thus a featural processing strategy was sufficient to maintain accuracy performance. However, under task conditions with greater time restrictions a featural processing strategy may result in reduced accuracy as well as longer response times in schizophrenia. The difference in featural verses configural processing in schizophrenia will be examined in greater detail in the following chapter.

For the labelling task, the results were consistent with previous literature suggesting that facial expressions of happiness were easier to recognise than expressions of the negative emotions such as fear, anger and sadness (Edwards et al., 2002), this was apparent for both healthy controls and schizophrenia patients. As discussed, facial expressions of happiness typically involve a relatively unique appearance of the facial muscles resulting in easier recognition, a
finding confirmed by the current study. This may indicate that happy faces are easier to recognise using featural processing strategies. In comparison, there is greater overlap of facial muscles moving for negative emotions making them harder to differentiate between as they potentially require more configural processing to aid in recognition.

The schizophrenia patients differed in performance to controls for all emotions except happiness, thus as predicted the results do not lend support to the ‘emotion-specific deficit hypothesis’. As indicated above, the performance for happy faces tended to approach ceiling, as the unique featural information specific to happy faces rendered them ‘easier’. It appears that the schizophrenia patients showed a generalised emotion deficit, with the exception of the more featurally processed and ‘easier’ happy faces. This was in partly in agreement with predictions. A generalised negative-emotion deficit is consistent with previous findings (Brune, 2005; Kucharska-Pietura et al., 2005).

The emotion processing deficit shown by schizophrenia patients appears to be linked with difficulty as suggested by Johnston et al. (2006). Furthermore, the more ‘difficult’ emotional classes may require or result in different processing styles corresponding less to featural information and more to configural information. For example, schizophrenia patients showed particular impairment for emotional expressions of fear and sadness. These are the two emotions that share the most key features, and are thus more difficult to recognise. It is not surprising, therefore, that schizophrenia patients would show such impairment. Further, if emotional expressions of negative valence are more difficult and do indeed require more configural processing, this provides additional support towards the proposition that schizophrenia patients have a deficit in processing configural information.

Further support for this line of reasoning comes from the finding that schizophrenia patients did not appear to utilise extra available information when viewing the whole face compared to viewing the eye region alone, particularly for the expressions of fear and sadness, whereas controls did benefit from the extra information from additional available structures. Furthermore, controls on average showed faster response times for the whole face condition. In contrast, on average schizophrenia patients showed faster response times to the eyes only condition, suggesting information from the whole face did not speed up processing time. Schizophrenia patients may not be utilising (or integrating) information from other facial areas to aid in emotion recognition. This is in agreement with the visual scanpath literature that indicates
schizophrenia patients tend to show abnormal scanpaths during viewing of facial information (Loughland et al., 2002b; Streit et al., 1997; Williams et al., 1999), a finding also observable in first-degree relatives (Loughland et al., 2004). Assessment of visual scanpath involves videoo-oculography recordings of the pattern of eye movement and foveal fixations. A typical healthy control scanpath when viewing a face is shown below in the left panel of Figure 5. This characteristically involves a triangular pattern spanning information from each eye, down to the mouth and then back up to the eyes. In comparison, as shown in the right panel of Figure 5, schizophrenia patients demonstrate a restricted scanpath not representative of a methodical scan, involving shorter scan length and distance between fixations. This restricted scanpath for faces shown by schizophrenia patients may go towards explaining an impaired ability to configurally process information (Streit et al., 1997).

Figure 5. Visual Scanpaths to Faces: Healthy Controls (left) and Schizophrenia Patients (right)
Figures reproduced from (Loughland et al., 2002b, pp165)

The results of the current study indicated a negative association between emotion processing and age, suggesting performance deteriorates with increasing age. This relationship was only observable for controls and not consistent over emotion or condition. Others have also demonstrated such a relationship for fearful faces, and to a lesser extent sad and angry faces (Calder et al., 2003), whereas recognition of happy faces remains relatively preserved. Results also indicated performance was not related to gender for either healthy controls or schizophrenia patients, however, this result must be interpreted with caution as there were only eight female schizophrenia patients. Nonetheless, these results are in agreement with a previous review indicating no consistent effects of gender or age on emotion processing (Edwards et al., 2002).
While some studies have revealed a female superiority for healthy controls (Montagne et al., 2005; Thayer & Johnsen, 2000) and schizophrenia patients (Scholten et al., 2005; van't Wout et al., 2007), others have demonstrated no such relationship (Muzekari & Bates, 1977) and others have found females to perform worse than males (Gessler et al., 1989).

Further, against predictions, task performance for the schizophrenia patients showed no relationship to negative symptomatology (or in fact any symptom characteristics). This is inconsistent with a section of the literature (Gur et al., 2006; Mandal et al., 1999). There are several explanations for this discrepancy. Firstly, the schizophrenia patients from the current work were all outpatients and thus, as discussed in the previous chapter, may be more likely to be higher functioning than patients from other samples. Likewise, the current sample may not show a great enough distribution of symptom severity to elucidate a relationship with emotion processing. Furthermore, the tasks here involved basic emotion discrimination and labelling and thus, may not have been as demanding as tasks from other studies that have revealed a correlation with emotion processing and negative symptomatology. Alternatively, the lack of association between emotion processing and negative symptomatology may simply reflect the heterogeneity of the disorder. There were also no significant correlations between task performance and GAF scores. As indicated in the previous chapter the GAF may not have been sensitive enough to reveal specific relationships between emotion processing and functioning. Future studies should investigate more complex measures of functioning. There were also no significant relationships between task performance and length of illness or medication.

4.7.1 Limitations

The current study had several limitations worthy of comment. Firstly, the PoFA stimuli used to develop the emotion discrimination and labelling tasks involved static posed photographs. Although these stimuli have the advantage of being rated consistently as belonging to an emotional category, they do not represent spontaneous dynamic expression, bringing into question the ecologically validity of the results (Gosselin et al., 1997a). Encouragingly, recent work has begun to explore the role of static verses dynamic and posed verses spontaneous stimuli within the research design. Results have indicated performance deficits on both static and dynamic facial images as well as a double dissociation with symptomatology; negative symptom severity related to poorer performance on static faces and positive symptom severity related to poorer performance on dynamic faces (Johnston et al., 2008b).
A further issue within the current work was the limited viewing time for stimuli discrimination and labelling. As indicated, some studies have involved very brief presentation time whereas others have placed no restrictions on viewing time. Schizophrenia patients have been reported to show a general cognitive slowing, and may become anxious if stimuli are presented too quickly; therefore, it is not appropriate to use very short presentation times. Further, real-life facial emotional expression is brief and rapidly shifting so unlimited viewing is not appropriate either. Consequently, while some would consider the limited viewing time a limitation, the current study was designed to be a compromise between task difficulty, ecological validity as well as sensitivity to reveal subtle group differences in performance.

Lastly, one other limitation of the current study concerned the ethnicity of the facial stimuli used in each of the emotion processing tasks. All test faces were Caucasian despite two participants (one control, one schizophrenia patient) being from Asian background (although all with English as a first language). It is therefore possible these two participants may have been disadvantaged on these tasks. There is substantial evidence to indicate individuals are more effective and efficient at recognising faces from their own race over those from a race different to their own (O’Toole et al., 1994) and even from a species different to their own (Pascalis & Bachevalier, 1998). The extent of this effect was not predicted to be of great consequence on the current results as there were only two participants concerned (one from each group), and both had been raised in Australia since a young age, and were thus very familiar with the characteristics of Caucasian faces.

4.7.2 Treatment Implications

The facial emotion recognition deficit in schizophrenia has shown limited improvement with conventional treatment approaches such as pharmacological therapy (Lewis & Garver, 1995). There is some remediation of social skills with the use of non-social cognitive training such as cognitive behavioural therapy (CBT) (Gumley et al., 2003); however, the majority of evidence suggests that CBT provides limited generalisability to improvements in social functioning for schizophrenia patients (Cather et al., 2005). As a consequence, researchers have attempted to develop social cognitive intervention programs to either broadly implement social skill training (van der Gaag et al., 2002) or target particular domains, for example emotion processing (Combs et al., 2008; Frommann et al., 2003; Russell et al., 2006; Silver et al., 2004; Wolwer et al., 2005). The Training of Affect Recognition (TAR), for example, involves a 12 session program with
each session lasting 45 minutes. The program is designed for patients to work together in pairs learning to identify and discriminate emotional information in increasingly social, transient and ambiguous situations. Trials of the TAR have demonstrated that patients who were below normal for emotion recognition before treatment improved to within the normal range after treatment. The TAR proved to be more effective than CBT or only pharmacological treatment over a six week period (Wolwer et al., 2005).

Results from the current work may contribute to the development and direction of other social cognitive remediation strategies. For example, these results highlight the importance of viewing information from the eyes in context of the whole face. Furthermore, the schizophrenia patients showed impaired performance over a range of different emotional expressions. Thus, issues to consider when designing a remediation program include the significance of viewing the face as a whole rather than a sum of constituent parts, and a focus on accurate differentiation between emotions, particularly negative emotions. Further, deficits are observable over different response forms, thus remediation should consider basic discrimination as well as labelling. This will be considered in greater detail in following chapters. Finally, it must be noted that although social cognitive remediation programs provide promising results, at this stage, such tools are best integrated with existing pharmacotherapy and CBT.

4.8 Summary

The current results confirmed that schizophrenia patients show deficits in facial emotion processing for both discrimination and labelling of facial expression. Although deficits were more pronounced for some emotional categories than others, the results are discussed in terms of a generalised performance deficit due to the fundamental characteristics and ceiling effects observable for the easier emotional categories i.e. happiness. Researchers in support of the generalised deficit hypothesis suggest impaired emotion processing in schizophrenia may reflect the indirect influence of lower-order perceptual difficulties particularly pertinent to face perception.

Considering certain parts of the face are more important for the identification of different emotional expressions (Mandal & Palchoudhury, 1989), it is clear that effective emotion perception requires an encoding of the whole faces. Compared to controls, schizophrenia patients did not perform as well for whole faces than eyes alone. The current chapter discusses a
difference in perceptual style, configural versus featural processing, between schizophrenia patients and controls and the influence this may have on facial emotion processing. Inefficient processing styles may result in reduced information extraction from the whole face which may adversely affect the ability to perceive the emotion within the face. The following chapter will consequently investigate this experimentally in greater detail. Thereafter, Chapter 6 will address the overall relationship between emotion processing, facial processing and neurocognition.
Chapter 5  Face Processing in Schizophrenia

The previous chapter detailed the facial emotion processing impairment shown in schizophrenia. As discussed, deficits in performance may reflect a generalised impairment that is common to perception of all facial information. The relationship between emotional and non-emotional face processing is considered via both the ‘Independence hypothesis’ and the ‘Interactive hypothesis’. The Independence hypothesis posits that facial recognition and facial emotion processing are separate, independent and parallel processes, whereby separate brain processes exist for facial information such as identity, emotion and familiarity (Bruce & Young, 1986). This theory indicates that variation in facial identity during a facial emotion task has no impact on responses to emotional content (Young et al., 1986). The Independence hypothesis has received support from neuroimaging studies, indicating different areas of the brain are responsible for face and emotion processing (Sergent et al., 1994). Despite this viewpoint, recent studies have begun to explore the notion that face recognition and emotion recognition may interact. This ‘Interactive hypothesis’ posits that facial recognition and facial emotion processing are interrelated; suggesting that variation in facial identity during a facial emotion task may interfere with the responses to the emotional content (Baudouin et al., 2002). This theory has received support from studies that indicate a correlation between performance on face recognition and emotion recognition tasks (Schweinberger et al., 1999; Schweinberger & Soukup, 1998). Based on this recent literature, it is apparent that the investigation of non-emotional face perception is particularly important. Therefore, the current chapter will discuss the different underlying processing strategies used to perceive facial information, and unlike the previous chapter will not be related to the emotional content of the face.

The current chapter is presented in five main sections. 1) A review of the literature on healthy face perception, including the significance, development and processing strategies involved, 2) a review of the limited research into face processing (of non-emotional content) in schizophrenia, 3) a statement of the aims and hypotheses relating to the empirical investigations of the current work, 4) a description of the methods, results and interpretation of five tasks assessing featural, first and second order configural, and holistic aspects of face processing, and lastly, 5) a discussion and integration of these results in relation to a model of face processing in schizophrenia.
5.1 Background to Face Processing

Through visual perception of facial information, not only do we recognise a face as familiar or unfamiliar, we can identify gender, age, ethnicity, current mood or emotional state, gaze direction, alertness and impending behaviour, often all accomplished with a mere glance (for a review see Bruce & Young, 1998). Despite the omnipresent nature of faces, humans are able to distinguish hundreds of individuals from each other, notwithstanding each face sharing the same general configuration with the potential to look very similar. We are able to recognise unfamiliar faces after only very short exposure. Further, our recognition of faces is flexible; we are able to identify individuals despite interference from poor viewing conditions, lighting, crowds, or movement. We can recognise people regardless of changes in age, hairstyle, the presence of facial hair, or glasses. Bahrick, Bahrick and Wittlinger (Bahrick et al., 1975) revealed that participants were very accurate (90%) in their ability to identify and match names to faces of their former school classmates from at least 15 years prior. Carey, Diamond and Woods (Carey et al., 1980) indicated that facial encoding dramatically improves from the age of six onwards and this improvement is related specifically to faces as opposed to generalised encoding skills such as memory and pattern recognition.

As indicated in section 4.2, Bruce and Young (1986) and Haxby et al. (2000) have proposed cognitive models of face processing which have been particularly influential in driving subsequent investigations. Bruce and Young indicate that face perception involves a number of distinct stages and independent sub-processes. Incoming information from a target face is ‘structurally encoded’, whereby information about the facial features and characteristics is processed. Familiarity recognition occurs by matching this structurally encoded information with that previously stored in memory as ‘face recognition units’. The match is considered as unfamiliar, true recognition, or resemblance. ‘Person identity nodes’ are accessed and provide semantic information specific to the recognised individual, such as their name. Haxby et al. extends upon the Bruce and Young model by including the neuroanatomical substrates to the face perception process. Haxby et al. indicates that face perception occurs via a core system whereby basic analysis occurs in the visual cortex; representation of facial features is mediated by neurons in the inferior occipital gyri; identity is mediated by the lateral fusiform gyrus; perception of variable (dynamic) facial information, i.e. eye gaze, is mediated by the superior temporal sulcus. This information combined is then interpreted by an extended neural system including the amygdala and prefrontal cortex which permit perception of meaning, such as emotion.
Consequently, these models suggest that processing facial information may be a specialised function.

Consistent with this notion, prosopagnosia is a condition involving a selective impairment for face recognition, not only of friends and relatives of the individual in some cases even of their own face. Considering perception of other non-facial stimuli remains intact, this condition suggests that face perception may be a relatively specialised process (Gruter et al., 2008). This condition can occur after damage to the fusiform gyrus (occipito-temporal) of the central visual system of the cerebral cortex. The specificity of prosopagnosia has led some researchers to claim the existence of brain structures specific to faces which are either destroyed or damaged in patients with prosopagnosia.

Researchers have revealed specific areas of the brain that preferentially respond to face stimuli to a greater extent than any other stimuli class. Specifically, bilateral regions of the lateral middle fusiform gyrus have been termed the ‘fusiform face area’ (FFA) (Kanwisher et al., 1997). Additionally, other areas such as the right inferior occipital gyrus (occipital face area; OFA) and the superior temporal gyrus are also considered to play a significant role in the processing of facial information (for a review see Haxby et al., 2000). Furthermore, electrophysiological studies have indicated the bilateral occipito-temporal Event-Related Potential (ERP) known as the N170 is consistently greater in amplitude upon viewing faces compared to non-facial object stimuli (Batty et al., 2009a; Batty et al., 2009b; Bentin & Allison, 1996).

These factors combined with growing empirical evidence from other behavioural, neuroimaging, and lesion studies suggest that the cognitive mechanisms behind face perception may be functionally specific and different (albeit related) to those of other visual stimuli.

5.1.1 History of Face Processing Research

The fascination in human face perception has existed for some time, for an early review see (Goldstein, 1983). Dating as far back as 1806, Charles Bell (1806) first documented the role of certain muscular regions within the face and their role in facial expression. Franz Joseph Gall (1835) extended his phrenological view of the skull to also describe the significance of various featural regions of the face. It was Darwin however, who through “The Expression of Emotions in Man and Animals” signified the role of facial emotional expression on evolution of
the human species (Darwin, 1872). Darwin postulated humans possess innate, universal expression of emotion. Based on this concept there has been extensive work investigating face processing in infants. Infants can recognise a stimulus as a face at a young age despite having restricted visual facilities and undeveloped cortical areas for visual processing. Newborns preferentially gaze longer at facial stimuli than non-facial stimuli (Valenza et al., 1996). Newborns are even able to discriminate between their mothers’ face and unknown faces (Bushnell, 2001). Further, it has been demonstrated that newborns spend longer looking at ‘attractive’ than ‘unattractive’ faces (Slater et al., 1998). By 2-months of age infants show the first signs of cortical specialisation for facial information (Tzourio-Mazoyer et al., 2002). Although there remains conjecture surrounding the specific mechanisms underlying face perception, there is substantial evidence lending support to Darwin’s claims; humans do appear to have some innate ability to process facial information.

While the discussion of face processing was largely atheoretical up until the mid-1970’s empirical investigation into the psychosocial significance of faces has since increased dramatically and there are now whole issues of journals dedicated to face research. The majority of this research has focussed on facial emotional expression; however, there is limited, but growing investigation into the specific processes underlying how humans perceive a face, and how this is different to other classes of visual stimuli. Some have deemed the human face an ‘ambiguous stimulus’ as all faces share very similar visual structure and belong to a group with numerous different members (Damasio et al., 1982). Cognitive models have provided comprehensive accounts of the information processing steps of face recognition (Bruce & Young, 1986; Ellis, 1986). These include encoding the physical structures into age, sex, race etc as well as integrating contextual, vocal and gait information with memory traces. The current chapter addresses the early classification and detection of a face, this is referred to by such face processing models as ‘structural encoding’ or ‘face register’. The following sections discuss the visual processing styles pertinent to face perception.

5.1.2 Featural Face Processing

Early investigations into face processing focussed on the separable elements of the face (Ellis et al., 1975; McKelvie, 1976). This early work revolved around a ‘Featural hypothesis’ of face processing, suggesting that faces are processed simply via a composition of individual components that can be observed in relative isolation e.g. eyes, nose, mouth, hair. Accordingly,
face identification and recognition occurs by processing information regarding the specific size, shape, texture, and colour of the facial elements. One study strongly supporting the featural hypothesis used schematic faces to test participants (albeit only six) in the ability to judge similarity of facial information (Tversky & Krantz, 1969). Results indicated the overall impression of a face was made via a composite of sub-impressions regarding featural information. Others have indicated this “provides strong evidence that facial features do not interact with each other and hence the overall impression can be understood as being sum of the independent components” (Sergent, 1984, pp222).

The featural hypothesis is the basis behind tools such as the Identi-kit (US) and the Photo-fit (UK), which are face reconstruction kits initially developed for the police force. Such tools consist of interchangeable alternatives of the hair and forehead, eyes and eyebrows, nose, mouth and lips, chin and cheeks, allowing for multiple variations of a composite face. Using the Identi-kit, researchers have suggested that face perception occurs via serial processing of facial components rather than as a unitary figure or a parallel processing of multiple components (Bradshaw & Wallace, 1971).

Feature saliency research has indicated that not all components of the face carry the same weight of importance to assist in recognition. One particular study used the Photo-fit kit to compare a target face with a novel face which differed in only one particular feature (Davies et al., 1977). By comparing the pattern of response for the different feature replacements, the researchers revealed that features towards the top of a face i.e. forehead and eyes, were the most informative for face perception followed by the mouth, chin and then nose. The eye tracking literature corresponds with these results, indicating that visual perception of a face relies heavily on the information from the eyes. Other studies report results consistent with this attentional bias towards the eyes (Guastella et al., 2008). Furthermore, as discussed in the previous chapter, some studies have found particular areas of the face are more important for certain expressions of emotion than other areas (Mandal & Palchoudhury, 1989). Interestingly, Karayanidis et al (2009) demonstrated that children look more to the eyes for identity matching, and to the mouth more for emotion matching.
5.1.3 The Face Inversion Effect

Early interest in face processing gave way to a pivotal finding known as the Face Inversion Effect (FIE) (Yin, 1969). The FIE illustrates that face recognition is disproportionately impaired when stimuli are inverted compared to other mono-oriented classes of visual stimuli. Compared to pictures of houses, men in motion, airplanes, as well as bridges and costumes (Yin, 1970) and even ‘cursive script’ (Rock, 1974), faces are easiest to recognize when presented in an upright orientation, however, most difficult when presented in an inverted orientation. Further, Yin reported that those individuals who were most accurate in their recognition of upright faces showed the least accurate performance on inverted faces. Although inversion impaired recognition for non-face stimuli (up to 10% difference between upright and inverted stimuli), this effect was to a much greater extent for face stimuli (up to 25% difference between upright and inverted). This finding has been replicated comparing dog faces and buildings with human faces (Scapinello & Yarmey, 1970) as well as comparing landscapes and houses with human faces (Diamond & Carey, 1986). The FIE is similar for familiar and unfamiliar faces (Collishaw & Hole, 2000). The FIE highlights the unique properties of facial information and paved the direction for more detailed investigations.

Several questions have emerged upon inspection of the FIE. Firstly, why does inversion affect our ability to process faces specifically? Further, are our processing styles different for faces compared to these other classes of stimuli? And if so, how are these processing styles different? Yin (1969) held a fairly strong viewpoint, and suggested that face recognition employs encoding processes specific to faces that are not used for any other stimulus class. Interestingly, subjective reports by the participants from this study reported two main strategies used to recognize the stimuli with which they were presented. To recognize the houses, figures of men in motion and airplanes, the participants reported searching for a distinguishing feature. In comparison, to recognize the faces they tended to form a general impression of the whole picture. When the faces were inverted, none of the participants indicated that they used the whole picture strategy for recognizing the inverted faces. These subjectively reported strategies led to exploration of featural face processing in the FIE (Endo, 1982). Using the feature saliency techniques discussed above (Davies et al., 1977), Endo found that the ‘most important’ features for face perception were constant irrespective of whether the face was presented upright or inverted. Thus, inverted face perception appears to utilise featural processing styles, and as a result inversion bears no impact on feature saliency. This conclusion is somewhat consistent with the subjective
participant reports from Yin. Participants did not report a tendency to use whole picture strategies for inverted face and may consequently have been relying on featural information. If featural information is available and valuable for inverted face perception, it suggests that the featural hypothesis of face perception is not proficient in explaining why face perception is impaired for inverted faces.

Although the featural hypothesis cannot explain the FIE, perception of distinctive facial features clearly plays a role in face recognition, for example Prince Charles’ ears, Barbara Streisand’s nose or John Travolta’s chin. However, considering the homogeneity of human faces with distinct overlap in featural characteristics it is not surprising we require more than featural information for face recognition. If we base our face perception solely on the recognition of featural information, we would not be able to distinguish the large number of faces that we do, nor would we be flexible to recognise changes in facial information over time. Up until the mid-1970’s, the question remained; how does inversion affect our processing style for facial information? Some have suggested that inverting a face may interrupt overall typical scanning strategies (Ellis, 1975). Similarly, others have proposed that humans are egocentrically attuned to orientation and, as a consequence have adaptive strategies to mentally correct non-upright images (Rock, 1974). This automatic mechanism of mental rotation can be ‘over-taxed’ and thus results in distorted perception. It was further noted that the spatial relationships between features of a face are also important; the large number of spatial relations requiring correction would indeed overtax the perceptual system during inversion. In this sense, Rock did not appear to consider that assessing spatial relations was a separate type of information processing, but rather as a combination of numerous discreet elements. Although still approaching face processing from a featural point of view Rock definitely noted the importance of spatial information and considered each spatial relation as a separate element eventually requiring integration.

The notion that the spatial relationships between the components of a face may be just as important for face perception as the individual components themselves had been documented as early as 1879 (Galton, 1879). Others have commented on the possibility of a differential response to presentations of fractional information from partial regions of the face compared to the whole face (Ellis, 1975). The subjective reports from initial FIE investigations also alluded to the importance of the relationship between facial features to develop a ‘whole picture’ for face recognition (Yin, 1969). As a consequence, the progression of research turned from examination
of the features of a face in isolation, to the spatial relationship between these features (Bradshaw & Sherlock, 1982; Haig, 1984). Such work led to the development of the ‘Configural hypothesis’ of face processing, positing that faces are processed via more than simply adding individual features together. This hypothesis stresses the importance of the configuration or spatial relationships between the facial features.

5.1.4 Configural Face Processing

Configural face processing has been investigated in a number of ways. One particularly elegant method has been to disrupt the configural information within the face (Haig, 1984). In Haig’s study, participants were presented with a series of modified faces. These modified faces had been configurally altered such that the spacing of the features was changed (eyes up/down, mouth up/down, nose up/down, eyes narrow/wide, mouth narrow/wide). After a familiarisation phase of non-modified faces, participants completed the test phase whereby they were required to indicate whether each face was a modified or original face. Results indicated (albeit from five participants) that altering the configural information of a face had significant impact on the perception of that face. As noted by Haig, these results bring into question the validity of using featural face reconstruction kits such as ‘Photo-fit’. These tools place the importance in face recognition on the discreet features without emphasising the relationship these features have relative to each other.

Configural processing during face perception has been investigated using other methods. The most common and valid technique involves the systematic alteration of facial stimuli to develop two ‘sets’ of faces, featural and configural, which are presented in both upright and inverted orientations. Sets of featural manipulation involve one particular face which is then multiplied and altered by pasting the nose, eyes and mouth of other faces over the top of the original face. Similar configuration is maintained for each of the stimuli and they consequently differ only in featural information. Conversely, sets of configural manipulation, as discussed above (Haig, 1984), involve one particular face that is multiplied and altered by moving the eyes up, down, in or out, and the mouth up or down. Thus, the featural information is maintained, however, the configural information changes. This ‘featural-spacing manipulation’ method of experimentation was employed in the current thesis, and is described in greater detail in section 5.4.2.
Using the featural-spacing manipulation technique with schematic faces, Sergent (1984) was one of the first to directly investigate the effect of both featural and configural (spacing) alterations on face perception. Her results indicated a significant interaction between featural and configural conditions, in that the manipulation of featural information impacted on the differentiation of faces based on configural information and vice versa. It was concluded that facial features are not processed independently of one another, and that each face is different as a result of the components themselves as well as the relationship between these components. Interestingly, this featural-configural interaction was only observable for upright faces and not those that had been inverted, which only relied upon featural information. Many researchers have since used the same technique to investigate featural and configural face processing with real, not schematic faces (Leder & Bruce, 2000; Searcy & Bartlett, 1996). More recently, Freire et al. (2000) indicated that only performance for configurally manipulated faces (spatial manipulations) was adversely affected by inversion, with a 26% fall in accuracy. Performance for featurally manipulated faces was not affected by inversion, with only a 1% difference in accuracy. Hence, the results indicate inversion disrupts configural information processing to a much greater extent than it does featural information processing.

Further insight into the role of configural processing in face perception and the effects of inversion has emerged from the ‘Thatcher Illusion’ (Thompson, 1980). A ‘Thatcherised’ face is an image of a smiling face in which the eyes (not including eyebrows) and mouth have been rotated 180°, see Figure 6. This alteration to an otherwise normal face results in a grotesque expression when it is viewed upright. When the whole image is completely rotated however, this grotesque expression disappears and is difficult to distinguish from a normal undistorted inverted face.

Figure 6. Unaltered Inverted Face (A), Unaltered Upright Face (B), Thatcherised Inverted Face (C), and Thatcherised Upright Face (D)
Interestingly, no FIE effects are observed for Thatcherised faces (Bartlett & Searcy, 1993; Leder et al., 2001). It appears that this illusion occurs because the internal inversion interferes with configural processing. As indicated, configural processing is disrupted with inversion and processing relies on featural information. The features in a thatcherised face do not appear to be different to those from an unaltered face, therefore, inversion does not impact on a thatcherised face. However, when the face is upright, both the configural and featural information are disrupted resulting in a grotesque appearance. This highlights how thatcherised faces reflect configural processing.

To summarise these results, upright face perception involves both featural and configural information. When the same face is presented upside down, the featural information does not change (i.e., the same eyes, nose, and mouth appear in both upright and inverted faces), however the configural information is altered. Hence, face recognition for inverted faces is reliant only on featural processing, which is more time consuming and less accurate, and results in impaired performance.

5.1.5 Development of Configural Face Processing

In an attempt to explain how configural processing transpires, researchers have proposed a developmental progression for this information processing style (Carey & Diamond, 1977). Investigations have indicated that 6-year-old children show difficulty recognising faces when the emotional expression of the face changes, whereas 10-year-old children do not show this difficulty. The researchers of this study suggested that the younger children did not perceive the face as a whole which resulted in impaired performance. The results further revealed that children below 10 years of age did not exhibit the FIE; these younger children were able to recognise inverted faces almost as well as upright faces. In comparison, children over 10 years of age showed better recognition for upright faces whereas performance for inverted faces was similar to that of the younger children, thus revealing a significant FIE. There was no such pattern of findings for pictures of houses. The researchers explain these results as indication of the development of efficient processing of upright faces via an increased ability to utilise configural information. The younger children used featural processing for both upright and inverted faces, however, the older children were able to process the configural information in the upright face yet reverted to featural processing when inversion occurred (Carey & Diamond, 1977).
From a similar developmental perspective, Brace et al. (2001) revealed that 2-4 year-old children were less affected by face inversion than were 6 year-old children and adults. Via similar featural-spacing manipulation techniques discussed above, others have indicated similar results revealing little developmental change for featurally altered faces, however, a clear developmental change for configurally altered faces (Mondloch et al., 2002). A greater FIE was apparent for adults and 10 year olds for the configural set indicating performance was compromised when configural information was disrupted. This was not the case for 6-8 year olds who showed a FIE equivalent for all manipulated face sets. Accordingly, this finding also suggests a developmental progression of configural processing styles for face perception.

Other researchers have challenged the claim that children do not utilise configural information for face processing. Several researchers have demonstrated that a FIE can be exhibited by children 5-8 years old (Pascalis et al., 2001), 5 months old (Hayden et al., 2007) and under certain conditions even as young as 4 months old (Turati et al., 2004). In line with this, others have shown featural-spacing manipulations have very similar effects for 7-year olds and adults (Freire & Lee, 2001; Gilchrist & McKone, 2003) as well as 4-year olds and adults (Pellicano et al., 2006). Others have indicated after habituation to a configurally altered face, 5 month old infants stared longer at a novel unaltered face when it was presented alongside the initially habituated face (Bhatt et al., 2005), indicating these infants were able to detect configural change. In comparison, three-month old infants did not differ in viewing time between the two face types, suggesting no detection of configural change. The researchers consequently explain that the development of configural processing appears to occur between three months and five months of age.

By testing whether children are sensitive to the ‘Thatcher illusion’, other researchers have also investigated the development of configural processing (Lewis, 2003). The results of such studies have indicated that children six years and older did discriminate between upright ‘Thatcherised’ faces and an unaltered face. However, when stimuli were inverted they did not make this discrimination, thus revealing comparable performance to adults. Similar findings have also been reported in newborns (Simion et al., 2007). Results involving the ‘Thatcher Illusion’ suggest that the ability to process configural information is available early on in life.

These developmental studies indicate, in spite of disagreement as to the precise time-course, it appears as though children are indeed able to utilise configural processing strategies. However,
as suggested by Carey and Diamond (1977), and more recently Simion et al. (2007), the preference for configural information may develop with age. Such a finding results in the following question: how does this development in configural processing occur?

5.1.6 Configural Processing and Expertise

Diamond and Carey (1986) have suggested that a preference for configural processing relates to the level of expertise the observer has for a particular stimuli class. The more experience we have discriminating objects of a particular category, the better we become at recognising stimuli from that category because we utilise additional processing styles, namely configural processing. Further, it has been suggested that the more we utilise configural information the more vulnerable the stimulus class becomes to inversion. As humans age, we become more familiar with faces (due to increased exposure) and thus develop more ‘expertise’ for this stimulus class. As indicated in 5.1.5, younger children do not use configural information to the same extent as adults. This is arguably because they are not as ‘expert’ with faces as adults are.

Scapinello and Yarmey (1970) presented participants with faces of dogs as well as human faces. They found the inversion effect for dog faces was not as great as for human faces. Diamond and Carey (1986) devised an interesting experiment presenting the same dog and human face stimuli, to two groups of individuals; dog novices (like those from Scapinello & Yarmey) and dog experts (breeders and judges). They reasoned that individuals not particularly familiar with dogs would not show a large inversion effect when presented with pictures of dogs as they do not possess the relevant expertise for this stimuli class, and hence only use featural processing styles which are available in upright and inverted orientations. Conversely, individuals who do possess an expertise for dogs would show an inversion effect for dog stimuli comparable to that of human faces. The results provided support for this reasoning. This effect has also been found for car experts who utilise configural processing strategies when viewing cars (Gauthier & Curby, 2005). Configural processing has also been observed in fingerprint experts (Busey & Vanderkolk, 2005) and handwriting experts (Bruyer & Crispeels, 1992). These results provide clear support for the ‘expertise’ theory that increased familiarity with a stimuli class leads to increased configural processing.

Further support for the expertise theory comes from the observation that human adults are better at recognising human faces than they are primate faces. Conversely, primates are better at
recognising primate faces over human faces (Pascalis & Bachevalier, 1998). This species specificity recognition is rationalised that each species has more expertise and experience with faces from their own kind, and thus better recognition. Similarly, from a developmental point of view, researchers have revealed that infants (6 months of age) are initially able to distinguish human and primate faces equally well (Pascalis & de Schonen, 1994). This is because they do not have an expertise for one over the other as they have not had the same level of exposure and hence familiarity with human faces. The researchers revealed this effect disappears by nine months of age when familiarity increases and expertise does develop, then the adult pattern of performance described above is observed.

Further to the expertise argument, adults show what is known as a ‘race-effect’. Recognition of faces belonging to one’s own race is better than that of faces from other races (O’Toole et al., 1994; Rhodes, 1993). Interestingly, infants have less decrement than adults for recognition of other races thus showing less of a ‘race-effect’ (Chance et al., 1982). As with the primate research discussed above, it seems that the ‘race-effect’ appears as exposure and thus expertise develops (Valentine, 1991).

The expertise argument, therefore, suggests faces are not a special class of stimuli in the sense that they involve processes specific to facial information. Rather, faces are special in that we have a level of experience with the stimulus category which may influence the visual system upon encoding. Further, expertise for different stimulus classes alters the associated processing strategies for those stimuli too.

5.1.7 **Neural Basis of Configural Face Processing**

*Laterisation*

The perception of facial information involves bilateral brain regions; however, laterisation studies have indicated that face processing styles differ between cortical hemispheres. Results have suggested right hemisphere dominance for configural information and left hemisphere dominance for featural information (Bourne et al., 2008). For example, PET studies indicate the right FFA is more activated during presentation of whole faces than parts of the face, whereas the left FFA is more activated during presentation of the parts compared to the whole (Rossion et al., 2000). Furthermore, electrophysiological studies have indicated the impact of configural
disruption via face inversion on the N170 ERP is particularly apparent in the right hemisphere (Rossion et al., 1999).

**Neuroanatomy and Stimulus Inversion**

The configural hypothesis of face perception has received additional support from neuroimaging investigations. As indicated, presentation of faces typically activates regions of the brain such as the FFA and the OFA. Interestingly, these areas are particularly sensitive to configural change (Rhodes et al., 2009). Furthermore, activation in these areas is reduced when faces are presented in an inverted orientation (Haxby et al., 1999; Kanwisher et al., 1998). In comparison, processing of non-facial objects (such as houses) activates medial regions of the cortex between ventral occipital regions and parahippocampal regions, however no differences in activation are observed in these areas when the objects are presented upright compared to inverted. Interestingly, results also indicate that inverted faces actually show increased activation in the same medial areas that respond to objects (houses). It is therefore suggested that recognition of inverted faces involves similar processes to object recognition.

Neuroimaging work also supports the notion that configural processing relates to the level of expertise an individual has with a particular stimuli class. For example, participants can be trained to expertly recognise structured non-facial objects, known as Greebles, as shown in Figure 7. These participants have shown similar patterns of brain activation in the FFA for presentations of faces and Greebles (Gauthier & Tarr, 1997). Further, these ‘Greeble experts’ also demonstrate an inversion effect for Greebles consistent with that of faces, in that Greeble inversion resulted in reduced FFA activation (Gauthier et al., 1999).

![Greebles](image)

Figure 7. Greebles
Other studies have indicated increased activation in the FFA for bird experts upon viewing pictures of birds (Gauthier et al., 2000). This challenges the notion of a ‘face-specific’ region in the brain, and suggests this area is actually specialised for stimuli with which we are especially familiar. For the majority of individuals this includes human faces, and for a select few also includes other classes of stimuli, for example birds. It could be argued then that the FFA is better conceptualised as a ‘configural processing area’ rather than face processing area.

Consistent with the expertise theory of configural processing, neuroimaging studies have also supported claims that older children (12-14yrs) show a developmental change in face processing compared to younger children (8-10yrs) (Aylward et al., 2005). For example, results indicate that older children show more activation in the FFA for faces than houses. This activation was correlated with age and a behavioural measure of configural face processing.

Electrophysiological investigations have also contributed to the understanding of the processes underlying face perception. The latency of the N170 ERP component is delayed when faces are inverted. Interestingly, parallel to the fMRI results, ‘Greeble experts’ also show a N170 delay for inverted Greebles (Rossion et al., 2002). These combined behavioural, neuroimaging and electrophysiological investigations on the effect of stimulus inversion clearly provide insight into the role of configural processing.

Lesion Studies

As discussed, prosopagnosia occurs after lesion to the fusiform gyrus resulting in a selective impairment for face recognition. Interestingly, research indicates that for prosopagnosia patients, recognition of inverted faces is relatively intact despite having impaired recognition for upright faces (Farah et al., 1995b). A complementary case study with a patient with visual object agnosia revealed that recognition of upright faces was intact, however, recognition of inverted faces was severely impaired (Moscovitch et al., 1997).

5.1.8 Models of Configural Processing

There are conflicting theories regarding the specificity of configural information processing. Some authors have proposed that visual stimuli are processed along a continuum from isolated features (for example, a bushy moustache or large nose) to relational information (Diamond &
Carey, 1986). The relational information is further divided into first-order (basic spatial relations between components, for example, eyes belonging above a nose belonging above a mouth) and second-order (size of these spatial relations, for example distance between the eyes or between the nose and mouth). Humans are particularly skilful at detecting first-order configural information of faces. This is highlighted by the artwork of Italian artist Giuseppe Arcimboldo who notoriously created portraits from fruit and vegetables (see Figure 8). Although the features within these portraits are themselves non-facial, the first-order configural information permits the immediate perception of a face.

![Figure 8. Italian artist Arcimboldo’s ‘Vertumnus’, a portrait of Rudolf II](image)

The robustness of first-order configural processing is further highlighted by the FIE. When a face is inverted we are still able to recognise the stimulus as a face. Therefore, inversion does not appear to effect the processing of first-order relational information. Considering all human faces share the same first-order information, it is the subtle differences in shape or spacing between features that make us individual. Accordingly, although inversion does not appear to effect the processing of first-order information, it does impede the processing of second-order relational information (Freire et al., 2000). Consequently, when a face is inverted specific recognition must rely upon the remaining featural information. Hence, the more reliant a stimulus is on second-order configural (relational) information, the more vulnerable it is to the effects of inversion.
Other researchers have proposed perception of stimuli dependent on configural information (such as faces) occurs through holistic processes. Consequently, that faces are viewed as wholes or ‘Gestalts’, and the features or individual parts of the face are not explicitly represented (Tanaka & Farah, 1993). Support for this viewpoint stems from several lines of evidence. Firstly, the ‘composite face effect’ demonstrates that individuals are less accurate and slower to respond to faces that have been composed from the top half of one face aligned with the bottom half of another face. Accuracy and response time is not as impaired when such a composite face is inverted or the top and bottom halves are misaligned (Hole et al., 1999; Young et al., 1987). Secondly, face recognition is more accurate when participants are first probed with a whole face compared to an isolated part. This effect, known as the ‘complete over part probe advantage’ (CPA), is not revealed when the task involves scrambled or inverted faces. The current body of work also investigated holistic processing using the CPA design and is detailed in section 5.4.4. Based on these results it has been concluded that the ‘composite face effect’ and the CPA both reflect holistic processing which occurred for upright faces, however, not for inverted faces, which do not involve the same holistic properties.

Although there is some clear overlap between the relational and holistic interpretation of configural processing, recent attempts have been made to operationally discriminate and integrate these terms. A review of the literature from Maurer et al. (2002) has concluded configural processing involves three key components. Firstly, sensitivity to first-order relations (e.g., recognizing that a face is a face because it contains two eyes above one nose above one mouth). Secondly, holistic processing involves ‘gluing’ the features into a Gestalt. Thirdly, sensitivity to second-order relations (e.g., perceiving distances that separate each of the facial features from the others). Others have taken this approach a step further to propose a time-based model of face processing, indexing the processing stages via ERP recordings (Latinus & Taylor, 2006).

The empirical evidence summarised above demonstrates that faces are indeed a special class of stimuli. Humans show an expertise for the perception of facial information, resulting in an increased reliance on configural processing styles. However, we are capable of possessing similar levels of expertise, and hence, processing styles, for other classes of objects. Thus, configural processing is not a process exclusive to facial information. Furthermore, face processing clearly utilises both featural and different aspects of configural information. The experiment reported in the current chapter was designed to use tasks assessing the three aspects of configural
processing detailed by Maurer et al. (2002) as well as featural processing. The aim of these tasks was to assess how first-order configural, second-order configural, holistic and featural information integrate together to permit face perception, both in healthy controls and patients with schizophrenia. The tasks chosen to represent the aspects of processing will be described in further detail below.

In summary, investigations into face processing are complicated by overlapping terminology such as ‘configural’, ‘relational’ and ‘holistic’. This makes the integration of the results challenging. Despite this overlap in terms, the differentiation between featural and configural face processing remains advantageous in understanding deficient face perception in clinical populations. Accordingly, the following section discusses the role of featural and configural processing in regards to face perception in schizophrenia.

5.2 Face Processing in Schizophrenia

Neuroimaging and electrophysiological studies provide strong evidence that schizophrenia patients show neural abnormalities while processing facial information (Bleich-Cohen et al., 2009; Walther et al., 2009). For example, first-episode schizophrenia patients have shown reduced grey matter volume in bilateral regions of the FFA (Lee et al., 2002). This has also been shown in chronic schizophrenia patients, and the degree of this reduction was significantly related to the degree of impairment on a facial memory task (Onitsuka et al., 2003). Functional MRI studies have indicated reduced activation in the FFA during face matching (Quintana et al., 2003). Schizophrenia patients have also shown a reduction in the face-specific ERP, the N170 while viewing facial stimuli (Herrmann et al., 2004). Patients show abnormal N170 response to alteration in the spatial frequency of facial information, indicating altered early visual processing (Obayashi et al., 2009). Furthermore, Johnston et al. (2005) demonstrated both fMRI bold reductions in the FFA and amplitude reductions in the N170, these reductions were correlated.

Schizophrenia patients have shown consistent behavioural disturbances in processing facial information, with the majority of literature investigating emotion perception as described in the previous chapter. Although there is considerable research into facial emotion processing in schizophrenia, there is relatively limited work on neutral (non-emotional) face processing (Chen et al., 2009). Questions have been raised regarding the specificity of emotion processing deficits and whether deficits actually reflect generalised perceptual problems associated with face
perception (Martin et al., 2005). The following section will consider the evidence for a
generalised impairment.

5.2.1 Differential Deficit Design

A differential deficit reflects greater impairment (relative to control group) in one function over
that of another function (Chapman & Chapman, 1989). A common limitation within
investigations of facial emotion processing in schizophrenia is the failure to implement a
differential deficit design. Without an appropriate design it is not possible to tease apart possible
deficits in facial emotion processing from those of general face processing. As suggested by the
interactive hypothesis of emotion processing it is possible that the facial emotion deficit
observable in schizophrenia could actually be a function of, or partially masked by, the deficits in
general facial processing. Hence, to explore facial emotion processing in schizophrenia we must
understand basic face processing. Therefore, this chapter aims to investigate the evidence
suggesting schizophrenia patients process faces differently to controls.

Although infrequent, some studies have employed a differential deficit design and have
consequently revealed interesting results regarding the interaction between emotional and non-
emotional face processing. Several studies have involved performance comparisons between a
standard test of facial recognition and a more complex emotion recognition task (Hall et al.,
2004). Results have revealed that schizophrenia patients showed intact performance on the facial
recognition task however impaired performance on the emotion task. Likewise others using
similar tasks reveal a significant difference in performance between schizophrenia patients and
controls after controlling for basic face recognition (Kucharska-Pietura et al., 2005; Penn et al.,
2000). Consequently, it has been claimed that emotion processing deficits are specific in
schizophrenia, and can not be accounted for by general face processing problems. The problem
with this interpretation lies with the fact that in the majority of these studies the two tasks being
compared were not psychometrically matched. In contrast, Gessler et al. (1989) reports a well
designed study that employed a non-emotion face task and an emotion face task which were
systematically equated on psychometric properties. Both tasks used similar facial stimuli, which
were of similar complexity and difficulty. The results did not reveal a specific deficit in the
processing of emotion for schizophrenia patients. Instead they indicated that performance was
impaired for both emotional and non-emotional dichotomous decision making. Further,
another study from Novic et al. (1984) revealed that the difference in emotion recognition
between schizophrenia patients and controls was no longer significant when facial recognition was entered as a covariate in the analysis. Others have provided support for a generalised deficit for face perception showing impaired performance on both facial affect tasks as well as facial identity tasks (Archer et al., 1992; Feinberg et al., 1986; Norton et al., 2009). Similarly, strong correlations between performance on facial emotion identification, facial emotion discrimination and facial recognition are observable for schizophrenia patients (Addington & Addington, 1998). Relationships between emotion and face processing in the current study are presented in section 6.2.2.

These findings suggest that facial emotion processing deficits in schizophrenia may at least, in part, be explained by the indirect influence of lower-order perceptual difficulties specific to face perception. It has previously been proposed that schizophrenia patients do not integrate the components of the face into a Gestalt, thus do not perceive the face as a whole, rather they use piecemeal strategies to aid in recognition (Frith et al., 1983). This is consistent with previous literature which suggests perceptual organisation, specifically grouping and integrating elements, is impaired in schizophrenia (Place & Gilmore, 1980; Silverstein et al., 2006; Wells & Leventhal, 1984).

As discussed in the previous chapter, schizophrenia patients typically exhibit abnormal visual scan patterns upon viewing faces (Loughland et al., 2002b; Streit et al., 1997). Instead of the typical triangular pattern of fixations, spanning the eyes and mouth, schizophrenia patients show a restricted scanpath with shorter scan length and shorter distances between fixations. This provides further evidence to suggest individuals with schizophrenia process facial information differently to healthy controls. Interestingly, however, Leppanen et al. (2008) indicated healthy controls and schizophrenia patients demonstrated a similar attentional bias towards the eye region of the face. This is inconsistent with the visual scan literature which suggests schizophrenia patients fail to attend to the eyes and other important features of the face that provide the most socially relevant information.

As indicated in section 5.1, healthy face perception relies heavily on configural processing strategies. Configural processing strategies involve a global, top-down approach whereby facial elements are considered relational to one another. Based on impaired performance deficits shown by schizophrenia patients on perceptual organisation tasks, it has been suggested that patients fail to utilise top-down (Gestalt) processing styles and rely on more fragmented and time
consuming, bottom-up or ‘local’ approaches for perception (John & Hemsley, 1992). Considering schizophrenia patients show impaired face perception, and demonstrate fragmented perceptual organisation, it is reasonable to suggest they may have an impaired ability to process configural information and rely on featural analysis.

5.2.2 Configural Face Processing in Schizophrenia

Investigation into configural face processing in schizophrenia is relatively new, and empirical research is limited. When the current research was first designed there was only one study investigating configural processing in schizophrenia. This study investigated the FIE in schizophrenia patients during a face memory task (Schwartz et al., 2002). The researchers found that patients exhibited a FIE similar to controls, and thus concluded configural processing was intact in schizophrenia. Since this thesis commenced, four other studies have been published in this area (Baudouin et al., 2008; Chambon et al., 2006; Chen et al., 2008; Shin et al., 2008).

Chambon et al. (2006) investigated the role of configural face processing in schizophrenia during emotion perception, and like Schwartz et al. (2002), also revealed the FIE for schizophrenia patients was similar to controls. However, they did reveal differences in discriminability and bias between upright and inverted face presentation. Furthermore the researchers suggested patients’ process upright and inverted faces componentially (i.e. featurally). They subsequently proposed that schizophrenia patients process configural information, however, of poor quality.

Interestingly, Chen et al. (2008) revealed that schizophrenia patients do show a reduced inversion effect for facial stimuli compared to healthy controls, however, the inversion effect for ‘tree’ stimuli was similar to that of controls. These results were thus contradictory to Schwartz et al (2002). The researchers concluded that “the efficiency of visual processing of facial information in schizophrenia is compromised” (pp5), and that the difference in inversion effect between stimulus classes indicates a deficit specific to facial information only. This deficit in face processing was not related to medication, IQ or education. There are several possible reasons why these results might contradict those reported by Schwartz et al. Firstly, Chen et al. used line drawings in a design requiring a response based on location judgement of stimuli that were presented very briefly. In comparison, Schwartz et al. used photographs in a design requiring a subjective response based on emotional expression or likeability of a face that were presented for a minimum of 5 seconds. Furthermore, the schizophrenia patients from both studies differed in
terms of recruitment source, chronicity and symptomatology. It must also be noted the results from Schwarz et al. were from several experiments based on sample sizes ranging from only 10-20 participants in each group, whilst Chen et al. had a larger group of N=29.

Another study assessing configural face processing in schizophrenia involved the featural-spacing manipulation methodology described above in section 5.1.4 (Shin et al., 2008). Participants were presented with two sets of faces, one that had been configurally manipulated, and one that had been featurally manipulated, as well as a set of chairs that had been featurally manipulated. When presented with two stimuli (either upright or inverted), participants were required to indicate whether the stimuli were the same or different. The results indicated that schizophrenia patients demonstrated impaired performance for discriminating upright faces, particularly those that differed configurally. Further, schizophrenia patients demonstrated a normal FIE for faces that different in featural information, however not for faces that differed in configural information. The researchers consequently concluded that schizophrenia patients show impairment in face perception due to problems processing configural information.

Baudouin et al. (2008) also used a set of faces in which the second-order configural information had been manipulated by changing the spacing distance between the eyes. The results of this study indicated that schizophrenia patients required a difference in the size of the spacing that was double that of control participants. Thus, schizophrenia patients were less sensitive to second-order configural change (of the eyes).

To summarise, there is growing evidence to suggest face perception is impaired in schizophrenia, and there are now several studies that suggest this may be associated with problems processing configural information. Despite this, to date no study has employed a multi-dimensional approach to thoroughly investigate the different face processing strategies utilised by schizophrenia patients. Therefore, parallel to the studies described above, the current study employed a combination of techniques to investigate featural and configural (relational and holistic) face processing in schizophrenia.

5.3 Aims and Hypotheses

The aim of the current chapter was to investigate whether schizophrenia patients demonstrate lower-order perceptual difficulties particularly pertinent to face perception. The lower order
abilities chosen for investigation reflect the review by Maurer et al. (2002) of key components of configural processing: first-order relations, holistic processing and second-order relations, as well as the distinction between featural and configural processing. Specifically, this work will assess performance on measures of featural processing, first-order configural processing, second-order configural processing, and holistic processing in schizophrenia patients and compare performance to that of healthy control participants.

Considering previous suggestions that schizophrenia patients process information componentially, in a piecemeal manner, it was hypothesised that this group would exhibit intact performance on the featural processing task. Additionally, as schizophrenia patients do indeed recognise facial images as faces, it was hypothesised that they would also exhibit intact performance on the first-order configural processing task. In accordance with the literature reviewed above however, it was expected that schizophrenia patients would show impairment on tasks requiring second-order configural processing, resulting in an over-reliance on featural processing styles for face perception. Specifically, on tasks involving inverted face perception, schizophrenia patients would have a configural processing deficit, thus inverting faces would not adversely impact on their performance as much as it would for healthy controls. Therefore, schizophrenia patients should show less of a FIE than controls. Furthermore, reported deficient Gestalt processing in schizophrenia, led to the expectation that patients would show impairment on tasks dependent upon holistic information. Detailed predictions pertaining to specific task performance are reported below.

There are limited investigations into configural processing in schizophrenia, thus the current work additionally aimed to perform exploratory analysis on any relationships between demographic or clinical characteristics and deficient face perception in schizophrenia.

5.4 Face Processing Tasks – Methods & Results

The following tasks were administered to the two participant groups detailed in Chapter Two. Each task was designed to assess the different processing styles required for face perception. Each task was based on an existing literature, with the methodology from that literature being adhered to particularly in terms of the stimuli construction. However, as these tasks had not been investigated in a schizophrenia sample before, initial task piloting was completed to investigate the procedural features of each task. A group of approximately 20 healthy control
participants and two schizophrenia patients (different to those reported in the current thesis) completed each of the tasks to help determine specific presentation timing restraints suitable for the two groups. In general the response window for each task was longer than has been used in the previous literature to allow for longer response times typically reported in schizophrenia. Consequently, as these tasks were novel in methodology, no standard psychometric ratings were available i.e. reliability and validity. Unless otherwise stated the dependant variables of interest for each task were accuracy (% correct) and response time (ms) to correct responses.

5.4.1 Scrambled Faces Task

The Scrambled Faces Task was used to assess first-order configural face processing. To reiterate, first-order configural information refers to the very basic placement of face features common to all human faces, i.e. the eyes appear above the nose which appears above the mouth. This task was designed to disrupt first-order information, while maintaining featural and second-order configural information. As schizophrenia patients do recognise information as facial or non-facial, it was predicted they would show intact first-order configural processing, and thus exhibit a similar pattern of performance to that of healthy controls.

Method

The stimuli were chosen from the PoFA series (Ekman & Friesen, 1976) and involved 12 different gray-scaled emotionally neutral faces (six males, six females). Each face was presented as either normal, that is, with no alteration or disruption (‘face’ condition), or scrambled (‘non-face’ condition). Scrambled faces involved a disruption of the first-order relations. Images had been edited (using PAINT.net software) such that the normal first-order configuration of the eyes above the nose above the mouth was changed. This method was adapted from Baenninger, Experiment 2 (1994). Photo editing software was used to capture the eyes region or the combined nose and mouth region of the face. The locations of the two regions were then switched to preserve the featural information and the specific second-order configural information, i.e. the features remained the same shape and distance apart, however, were reordered in terms of location. Unlike Baenninger, the blurring tool was used to maintain continuity of skin shade. New scrambled ‘non-faces’ showed the nose above the mouth above the eyes, see Figure 9. Images were 290 x 390 pixels in size.
Participants were presented with a randomised sequence of normal or scrambled faces. Each face was presented in the centre of the screen for 2000 ms seconds followed by a fixation cross (+) for 1500 ms. Participants were told they were going to see a picture on the screen and they were to decide if the picture was a real face or not. Via a two-button press participants were instructed to respond as quickly and accurately as possible to indicate whether the picture was either a ‘face’ or a ‘non-face’. The buttons were labelled so participants would not forget which button was which.

After reading the instructions, participants completed five practice trials. Participants then completed 72 randomised experimental trials in total. Each face and associated scrambled face was presented three times, hence there were 36 ‘faces’ and 36 ‘non-faces’. The task took approximately four and a half minutes to complete.

Results

Mixed between-within groups ANOVA was used to examine task performance for the schizophrenia patients and controls. The within-factor variable included condition (non-scrambled face vs. scrambled face) and the between-factors variable included group (schizophrenia vs. control). Preliminary checks were conducted to assess the assumptions of normality, homogeneity of variance, and homogeneity of intercorrelations. There was an issue for each of these assumptions as indicated by significant values for the Kolmogorov-Smirnov normality test, Levene’s test of equality of error variance and Box’s M test of equality of covariance. However, considering the groups were equal in size, ANOVA is robust to violations of normality and equality of variance. Furthermore, ANOVA remained the best method for analysis as there is no non-parametric alternative for a mixed between-within design. There were no apparent floor effects, however, ceiling effects were reflected in the accuracy data for both groups for both conditions. One schizophrenia patient did not complete this task.
The means and standard deviations of each group are shown in Table 12. Overall, controls performed more accurately ($M=98.8$, $SE=1.3$) than schizophrenia patients ($M=94.4$, $SE=1.3$) ($F(1.55)=5.44$, $p<0.05$). Likewise response times were faster for controls ($M=687.7$, $SE=30.9$) than patients ($M=792.1$, $SE=31.5$; $F(1.55)=5.60$, $p<0.05$). There were no differences in performance between the face and scrambled face conditions overall, nor were there any group by condition interactions. Post-hoc independent samples t-tests confirmed schizophrenia patients demonstrated reduced accuracy for both the face ($t(55)=2.08$, $p<0.05$) and scrambled face ($t(55)=2.21$, $p<0.05$) conditions compared to controls, as well as increased response time for both face ($t(55)=-2.11$, $p<0.05$) and scrambled face ($t(55)=-2.50$, $p<0.05$) conditions compared to controls. There were no significant correlations between task performance and demographic or clinical characteristics for either controls or schizophrenia patients.

| Table 12. Schizophrenia and Healthy Control Performance on the Scrambled Faces Task |
|-----------------|-----------------|-----------------|
|                  | Schizophrenia ($n=28$) | Control ($n=29$) |
| Accuracy (% correct) |                  |                  |
| Face              | 93.8 (13.6)      | 99.1 (1.5)       |
| Scrambled Face    | 94.9 (8.4)       | 98.5 (2.0)       |
| Response Time (ms) |                  |                  |
| Face              | 793.4 (229.4)    | 691.6 (118.8)    |
| Scrambled Face    | 790.8 (198.0)    | 683.8 (116.6)    |

Interestingly, significant correlations between accuracy and response times for schizophrenia patients (ranging from $r=-.45$ to $r=-.58$, $p<0.05$), however, not for controls, suggested there may have been a speed-accuracy trade-off in performance. Considering the task was relatively easy, and group differences were not predicted, the analysis was re-run with a measure of attention used as a covariate. As indicated in the previous chapter, schizophrenia patients demonstrate particular impairments in attention which may have significantly contributed to this unexpected group difference in first-order configural processing. When the RBANS Attention Index score was used as a covariate, group differences no longer existed ($F(1,54)=0.312$, $p=0.579$). Thus, it appears as though the group difference on this task was reflected by deficits in attention, and not first-order configural processing.

Discussion

Initial analysis of the scrambled faces task established that schizophrenia patients were less accurate and slower to respond than healthy controls. However, when attention was controlled
for, no group differences were apparent. Further, there was no interaction between condition and group; therefore there were no differential effects of first-order configural disruption. Thus, as predicted, disruption of first-order configural information did not appear to be impaired in schizophrenia.

The observable ceiling effects indicated that the task was relatively easy for all participants. To increase the task difficulty level, the stimulus presentation time could be shortened. Further, future use of this task would benefit from an upright vs. inverted orientation comparison to confirm inversion does not impact on first-order configural processing.

In summary, after accounting for attention, schizophrenia patients did not show a differential deficit in the ability to distinguish faces from non-faces based on first-order information. This was not unexpected as patients tend to show much more subtle deficits in face recognition. Consequently, investigation into perception of the more subtle differences between faces is appropriate. Therefore, the following tasks were designed to assess the differences in featural and second-order configural processing in schizophrenia.

5.4.2 Featural-Spacing Manipulation Tasks

The Featural-Spacing Manipulation Tasks were used to assess the FIE after featural and configural change in schizophrenia patients and healthy controls. The tasks were similar to those described in section 5.1.4. Both tasks had the same design and face stimuli, however differed in the type of manipulation completed. The Featural task was designed to assess processing of facial elements (i.e. featural processing), while maintaining consistent configural information. As indicated, featural face processing refers to the shape, colour, size etc of the actual components of the face, such as the eyes, nose or mouth. Thus, the Featural task manipulated the actual features within the facial stimuli. The Spacing task in contrast, was designed to assess second-order configural face processing while maintaining featural and first-order configural information. As indicated, second-order configural face processing refers to the specific location of features in relation to one another; that is the spacing and distance between features i.e. the eyes, nose, mouth. Thus, the Spacing task manipulated the spatial distances between features.
As discussed, healthy upright face perception involves configural processing, and inverted face perception involves featural face processing. Therefore, the following predictions were made relating to performance of control participants:

A. Overall, upright faces for both the Featural and Spacing tasks would be processed more accurately and efficiently than inverted faces (i.e. FIE).

B. Further, this FIE would be more pronounced for the Spacing task than the Featural task. The difference in performance between upright and inverted faces would be greater for the Spacing than the Featural task.

Schizophrenia patients are argued to rely less on configural information for face perception than controls (Shin et al., 2008), thus, the following predictions were made:

C. Overall, schizophrenia patients would show less of a difference in performance between upright and inverted faces than controls (i.e. less of a FIE).

D. Overall, schizophrenia patients would show a greater deficit (i.e. reduced accuracy and increased response time) on the Spacing task than the Featural task.

E. Specifically, schizophrenia patients would show a reduced FIE for the Spacing task.

Method

Two stimuli sets were created using gray-scaled emotionally neutral faces from the PoFA series (Ekman & Friesen, 1976). One white adult female face was selected as the template face and manipulations were made (using PAINT.net software) in line with Freire et al. (2000). For the featural set, the eyes, nose and mouth were selected from four other female faces and digitally pasted over the features in the template face. Thus, four manipulations in addition to the template face were created, resulting in five distinct face images, see Figure 10. The eye-nose-mouth replacement features did not differ in brightness or contrast to the template face, a limitation of previous studies (Mondloch et al., 2002). Further, they were selected to closely match the iris size and width of the nose and mouth to that of the template face. This clearly altered the featural information within the original template face, while maintaining the
configural information as well as external features. While featural manipulation may result in slight alterations in the configural information, care was taken to minimise these changes.

For the spacing set, the eyes (and eyebrows) were either moved horizontally in or out by 2 pixels, or the eyes and mouth were moved vertically down or up by 3 pixels. Thus, like the featural task, four manipulations in addition to the template face were created, resulting in five distinct face images, see Figure 10. This disrupted the second-order configural information within the template face, while maintaining the featural and first-order information.

All face images were 320 x 480 pixels in size. During stimuli editing, the blurring tool was used to maintain continuity of skin shade. Therefore, all face manipulations were subtle resulting in normal looking faces with careful attempts made to avoid distinctiveness or grotesqueness.

![Figure 10. Featural Manipulation (top) and Spacing Manipulation (bottom).](image)

Face pairs were presented on the screen for eight seconds, followed by a fixation cross (+) for 500ms in between each trial. Participants were required to determine if the two faces presented were the same or different. This discrimination design was selected to minimise the memory demand apparent in other similar tasks (LeGrand et al., 2001). Responses were made via a two-button press. Participants were instructed to respond as quickly yet as accurately as possible to indicate whether the faces were the ‘same’ or ‘different’. As soon as the participant responded, the task progressed to the next trial. The buttons were labelled so participants would not forget which button was which.
After reading the instructions, participants completed three practice trials for each task. Thereafter, for both tasks, each of the five face images was paired with itself eight times and each other twice (once to the left, once to the right), creating a total of 80 face pairs, thus half the face pairs showed identical (same) faces and the other half showed different faces. Each face pair was presented in upright and inverted orientation, thus participants were completed 160 randomised trials for each task. The order of task completion was counterbalanced.

Results

Unlike the approach of previous studies (Freire et al., 2000), the Featural and Spacing tasks were incorporated into the one analysis. Considering both tasks shared the same design, this was appropriate to observe the differential effects of featural and configural manipulation on performance. Mixed between-within ANOVA was used to examine performance for the schizophrenia patients and controls on both the Featural and Spacing task combined. Within-factors variables included task condition (featural vs. spacing) and orientation (upright vs. inverted), the between-factors variable included group (schizophrenia vs. control). Post-hoc paired samples t-tests were performed to investigate any significant interactions. Preliminary checks were conducted to assess the assumptions of normality, homogeneity of variance, and homogeneity of intercorrelations. There were some issues of normality and homogeneity of variance, particularly for the accuracy scores for both groups on the Featural task. However, considering the groups were equal in size, ANOVA is robust to violations of these assumptions. There were no apparent ceiling or floor effects. One control participant and one schizophrenia patient did not complete the Spacing task, and were thus excluded from the overall analysis. The means and standard deviations of each group are shown in Table 13. The FIE for accuracy scores was determined by subtracting the percentage correct for inverted faces from that of upright faces, i.e. a larger accuracy FIE relates to a greater difference between upright and inverted conditions. The FIE for response time was determined by subtracting the time taken to respond (ms) to upright faces from that of inverted faces, i.e. a positive response time FIE indicates that participants were faster to respond to upright faces, whereas a negative FIE indicates that participants were faster to respond to inverted faces.
Table 13. Schizophrenia and Healthy Control Performance on the Featural and Spacing Tasks

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia (n=28)</th>
<th>Control (n=28)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accuracy (% correct)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Featural Upright</td>
<td>79.11 (17.35)</td>
<td>91.16 (12.23)</td>
</tr>
<tr>
<td>Featural Inverted</td>
<td>73.62 (17.45)</td>
<td>87.90 (10.41)</td>
</tr>
<tr>
<td>FIE</td>
<td>5.49</td>
<td>3.26</td>
</tr>
<tr>
<td>Spacing Upright</td>
<td>64.38 (12.71)</td>
<td>84.73 (9.80)</td>
</tr>
<tr>
<td>Spacing Inverted</td>
<td>55.13 (11.66)</td>
<td>74.87 (10.50)</td>
</tr>
<tr>
<td>FIE</td>
<td>9.25</td>
<td>9.86</td>
</tr>
<tr>
<td><strong>Response Time (ms)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Featural Upright</td>
<td>2100.27 (496.39)</td>
<td>1951.66 (446.43)</td>
</tr>
<tr>
<td>Featural Inverted</td>
<td>2121.12 (508.65)</td>
<td>2204.35 (427.12)</td>
</tr>
<tr>
<td>FIE</td>
<td>20.85</td>
<td>252.69</td>
</tr>
<tr>
<td>Spacing Upright</td>
<td>2231.72 (514.35)</td>
<td>2258.18 (426.13)</td>
</tr>
<tr>
<td>Spacing Inverted</td>
<td>1975.24 (700.37)</td>
<td>2486.39 (457.78)</td>
</tr>
<tr>
<td>FIE</td>
<td>-256.48</td>
<td>228.21</td>
</tr>
</tbody>
</table>

A summary of the following main effects and interactions is presented in Appendix 3.

**Main Effects**

Overall, controls performed more accurately \(\bar{M}=84.7, SE=1.9\) than schizophrenia patients \(\bar{M}=68.1, SE=1.9\) \((F(1,54)=36.62, p<0.001)\). There were however, no significant differences in average response time between controls \(\bar{M}=2225.1, SE=84.0\) and patients \(\bar{M}=2107.1, SE=84.0\).

All participants were more accurate for the Featural task \(\bar{M}=82.9, SE=1.9\) compared to the Spacing task \(\bar{M}=69.8, SE=1.3; F(1,54)=59.77, p<0.001\). Likewise, participants displayed quicker response times for the Featural task \(\bar{M}=2094.3, SE=60.1\) compared to the Spacing task \(\bar{M}=2237.9, SE=67.3; F(1,54)=9.54, p<0.01\).

Furthermore, all participants were more accurate for the upright faces \(\bar{M}=79.8, SE=1.5\) compared to the inverted faces \(\bar{M}=72.9, SE=1.5; F(1,54)=40.90, p<0.001\). However, there was no significant difference in response time for the upright faces \(\bar{M}=2135.5, SE=58.0\) compared to the inverted faces \(\bar{M}=2196.8, SE=66.1\).

**Interactions**

The analysis revealed a significant interaction between condition and orientation for both accuracy \((F(1,54)=11.36, p<0.01)\) and response time \((F(1,54)=10.78, p<0.01)\). Post-hoc t-tests revealed the accuracy FIE was significant for both conditions (featural: \(t(55)=3.33, p<0.01\),
spatial: $t(55)=7.15$, $p<0.001$). Further investigation, however, indicated that inversion disrupted accuracy performance to a greater extent for the spacing set (FIE=9.55%) than the featural set of faces (FIE=4.37%) ($t(55)=-3.37$, $p<0.01$). In terms of response time, there was a significant FIE (FIE=136.77ms, i.e. faster response to upright than inverted faces) for the featural condition ($t(55)=-3.43$, $p<0.01$). The FIE was not significant for the spacing condition (FIE=-14.14). Post-hoc t-tests confirmed the difference in FIE for the two conditions was significant ($t(55)=3.10$, $p<0.01$).

The analysis also revealed a significant interaction between condition and group for both accuracy ($F(1,54)=4.07$, $p<0.05$) and response time ($F(1,54)=10.52$, $p<0.01$). For the accuracy scores, post-hoc paired samples t-tests revealed that the difference in performance between the featural and spacing conditions was significant for both schizophrenia patients (difference=16.61%, $t(27)=5.71$, $p<0.001$) and controls (difference=9.73%, $t(27)=5.49$, $p<0.001$). However, independent samples t-tests confirmed this difference was significantly greater for the patients ($t(54)=-2.02$, $p<0.05$). For the response time data, post-hoc t-tests revealed control participants showed a significant slowing in response time for the spacing condition compared to the featural condition (slowing of 294.28ms, $t(27)=-5.33$, $p<0.001$). In contrast, schizophrenia patients did not show a significant difference in response time between upright and inverted faces (FIE=117.81). Accordingly, independent samples t-tests indicated the difference in response times between the two conditions was significantly greater for controls ($t(54)=-3.24$, $p<0.01$).

Results indicated there was a significant interaction between orientation and group for response time ($F(1,54)=23.88$, $p<0.001$), however not for accuracy. Post-hoc t-tests revealed that overall control participants showed a significant FIE as demonstrated by longer response times to inverted faces (FIE=-240.45, $t(27)=-8.64$, $p<0.001$). Interestingly, in contrast, schizophrenia patients did not show any significant difference in response time between upright and inverted faces (FIE=117.81). Independent samples t-test confirmed this large difference in the FIE for the two groups was significant ($t(54)=-4.89$, $p<0.001$).

The analysis also indicated there was a three-way interaction between condition, orientation and group for response time ($F(1,54)=7.57$, $p<0.01$), however not for accuracy. Considering the a priori hypotheses, and that the response time results indicated that the two participant groups
did not show the same pattern of performance, exploratory analysis was performed, for both accuracy and RT, to investigate the effect of inversion on performance for each group separately.

The accuracy data indicated a significant interaction between condition and orientation for healthy control participants \((F(1,27)=7.36, p<0.05)\), however not so for schizophrenia patients. Post-hoc t-tests were conducted to examine this difference; the results are displayed in Figure 11. Post-hoc t-tests revealed that for controls, a differential inversion effect was observable over the tasks, that is, there was a significant difference in performance between upright and inverted faces for the Spacing task \((t(27)=5.03, p<0.001)\), but not for the Featural task. For schizophrenia patients, there were no differential inversion effects, with the similar inversion effect scores observable for the Spacing task \((t(27)=4.50, p<0.001)\) and for the Featural task \((t(27)=2.62, p<0.05)\).
The response time data indicated a significant interaction between condition and orientation for schizophrenia patients ($F(1,27)=13.46$, $p<0.01$), however not for control participants. Post-hoc t-tests were conducted to examine this difference. The results are displayed in Figure 12. Paired samples t-tests revealed that for schizophrenia patients, a differential inversion effect was observable over the tasks; that is, there was a significant difference in performance between
upright and inverted faces for the Spacing task \( (t(27)=2.88, p<0.01) \), but not for the Featural task. Interestingly however, this result for the Spacing task did not reflect the typical FIE, the schizophrenia patients actually showed faster responses for the inverted faces than the upright faces. For the control participants there were no differential effects, with the same typical FIE observable for the Spacing task \( (t(27)=-5.75, p<0.001) \) and the Featural task \( (t(27)=-6.90, p<0.001) \).

![Schizophrenia patients](image)

![Control participants](image)

Figure 12. Featural and Spacing Task Performance – Response Time
For control participants, age was significantly negatively correlated with accuracy performance for inverted faces on the spacing task ($r=-.47$, $p<0.017$). Otherwise, there were no significant correlations between task performance and demographic or clinical characteristics for either controls or schizophrenia patients.

There were no significant correlations ($p>0.05$) between accuracy and response time for any of the conditions for either schizophrenia patients (ranging from $r=-0.299$ to $r=0.231$) or healthy controls (ranging from $r=-0.241$ to $r=0.191$).

**Discussion**

**Control Performance**

The following findings confirmed the predicted pattern of performance for control participants, thus indicating that the tasks appropriately assessed featural and configural face processing.

A. The control participants showed faster response times for upright than inverted faces (i.e. typical FIE), in both the featural and spacing conditions.

B. The control participants showed superior accuracy for upright over inverted faces (FIE) in the spacing condition compared to the featural condition.

These results show that healthy controls do process upright faces more efficiently than inverted faces. However, faces that have been featurally manipulated are not as vulnerable to this effect as faces that have been configurally manipulated. Therefore, these results confirm claims that face inversion disrupts configural processing but not featural processing (Leder & Bruce, 2000). Thus, it suggests that different mechanisms are involved in featural and configural processing. As these findings are observable during basic discrimination, with stimuli presented simultaneously, it implies that the processing differences between upright and inverted faces occur at the structural encoding stage of face perception rather than the storage stage; and therefore reflect perceptual differences rather than differences in memory retrieval.

The current results regarding control performance are consistent with previous findings (Freire et al., 2000), with the exception of the inverted faces in the spacing task. The current study reported accuracy for this condition at 75%, whilst Freire et al. reported substantially lower
accuracy at 55%. It is unclear as to why participants from the current study would be more accurate for this condition as the methodology and design was very similar between the studies, and results were relatively similar for the other conditions. Freire et al. did not report detailed demographic information on the participant sample; indicating only that participants were all introductory level psychology students with an equal proportion of males and females. It remains unclear whether a difference in sample characteristics would account for specific performance differences and why this would only be particularly apparent for one condition. Unfortunately a comparison with response time was not possible as this information was not reported by Freire et al. Other studies have demonstrated lower accuracy levels across all conditions, with a difference up to 5-10% in some instances (LeGrand et al., 2001). A possible explanation for this discrepancy may lie with the differences in task design. Both Freire et al. and the current study employed a relatively free-viewing design whereby the two faces were presented simultaneously. In comparison, the design of LeGrand et al. involved the two faces presented sequentially with the stimuli only presented for 200ms at a time. This design placed short-term memory demands on performance. Therefore, these differences in methodology may account for the reduced performance of the control participants compared to those of the current study.

A limitation of the current task design was that all the facial stimuli were based around one female face. Future investigations would benefit from a range of faces, both male and female. Some researchers have noted that by changing the featural information within a face, as done in the current task, automatic alterations are made to the second-order configural information (Rakover, 2002). Different features vary in size and shape resulting in changes between the features, for example a bigger nose may lead to less space between the eyes and nose. This is a reasonable argument, thus, particular care was taken in the selection of feature replacements to ensure these effects were minimised. Consequently, any secondary, incidental configural changes were extremely subtle.

Schizophrenia Performance
The following findings supported the notion that schizophrenia patients show deficits in configural face processing.

C. Schizophrenia patients did not show faster response times for upright compared to inverted faces (i.e. no FIE), in either the featural or spacing conditions.
D. Schizophrenia patients showed reduced accuracy for the spacing compared to featural condition to a greater extent than the control participants.

E. Schizophrenia patients actually demonstrated longer response times to upright than inverted faces for the spacing condition.

These results are in agreement with the only other study to employ this task design with a population of schizophrenia patients (Shin et al., 2008), and also supports the results of Baudouin et al. (2008). Shin et al. also indicated schizophrenia patients did not show a response time FIE, however unlike the current study this finding was also reflected by accuracy scores. Both Shin et al. and the current study indicated the spacing condition was more difficult for schizophrenia patients than controls, evidenced by lower accuracy. Interestingly, both studies revealed that schizophrenia patients actually showed faster response times to inverted than upright faces from the spacing condition, as opposed to the typical pattern of response times whereby impaired performance is associated with face inversion. These results show that schizophrenia patients do not process facial information in the same way as controls. In particular, patients are not as vulnerable to inversion effects, particularly reflected by quicker response time. This is an important finding as schizophrenia patients were actually relatively better on some aspects of this task than healthy controls. This challenges a confound present in many other studies whereby schizophrenia patients show generalised deficient performance. It also highlights the processing styles used by schizophrenia patients, indicating a potential reliance on featural processing and specific problems when facial discrimination relies on configural processing.

These results do not reflect a speed-accuracy trade-off, as participants did not respond quicker to inverted stimuli, nor were there any significant correlations between accuracy and response times for any of the conditions for either group. Importantly, there was no overall group effect on response time, thus task performance was not confounded by general motor slowing. Furthermore, the task required discrimination of stimuli, thus there was no demand on short-term memory, which as indicated in Chapter Three can be impaired in schizophrenia patients.

Although the results indicate impairment, there is evidence to suggest that schizophrenia patients are able to utilise configural information to some degree. These patients did perform above chance for the Spacing task which was solely reliant upon configural processing. Further, they
did show some inversion effects, albeit smaller than healthy controls. Therefore, rather than suggesting schizophrenia patients do not process faces configurally it is more appropriate to suggest they rely less on configural information and more on featural information for face perception compared to controls. To investigate this in greater detail, another method of configural disruption was explored.

5.4.3 Fractured Face Task

Comparable to the Spacing manipulation task, the Fractured Faces Task also assessed second-order configural processing, however via a more complex recognition design. The previous tasks demonstrated stimulus inversion did result in some reduction in performance for schizophrenia patients. Therefore, it was expected that the performance of all participants would deteriorate with configural disruption. However, it was predicted this performance deterioration would be more pronounced for healthy controls than schizophrenia patients, i.e. configural disruption was thus expected to impact healthy control participants more adversely than schizophrenia patients.

Method

The stimuli and task design were based on that of Moscovich et al. (1997). The experimental stimuli were 67 photographs of different famous faces. Each face was presented ‘fractured’ and ‘whole’. In the fractured condition, faces had been digitally cut into 5-6 segments. The segments were then spread apart. This ‘fracturing’ maintained featural information as the elements of the face remained intact. The first-order configural information was also maintained as the general organisation of facial elements was preserved (i.e. eyes above nose above mouth). The ‘fracturing’ did, however, disrupt the second-order configural information as the specific spacing and distances between facial elements was altered. An example face is presented in Figure 13. An extensive item analysis was performed on the images based on the results from control participants. Three faces that were not recognised by at least 50% of the sample were excluded. Consequently, the final experimental set included 64 faces. All images were presented on a laptop computer with a standard 15.4-inch screen.
Participan ts were initially required to simply identify a series of the fractured famous faces described above. They were then shown the faces in their whole form and were asked to identify the face again. Participants were given one minute to verbally give their answer, receiving one point for each correctly identified face. Thus, participants received scores for the fractured and whole conditions, each out of a total of 64.

Results

Considering the nature of the task, response time was not considered to be a valid performance measure. Therefore only accuracy rate (number correct out of 64) was included as a dependent variable within the task analysis. To ensure, that the two participant groups were matched for familiarity with famous faces, three outliers from each group were excluded from the analysis. Subsequent one-way ANOVA confirmed no significant group difference in performance for the whole face condition ($F(1,50)=2.84$, $p>0.05$), thus the two groups were equally familiar with the identity of famous faces.

A repeated measures ANOVA was used to examine task performance for the two groups. The within-factor variable included condition (fractured vs. whole) and the between-factor variable included group (schizophrenia vs. control). The means and standard deviations are shown in Table 14.

3 The following results have been peer-reviewed and published (Joshua & Rossell, 2009).
Table 14. Schizophrenia and Healthy Control Performance on the Fractured Faces Task

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia n=26</th>
<th>Controls n=26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractured</td>
<td>34.85 (2.23)</td>
<td>36.73 (2.23)</td>
</tr>
<tr>
<td>Whole</td>
<td>45.81 (2.15)</td>
<td>50.92 (2.15)</td>
</tr>
</tbody>
</table>

Analysis revealed no significant overall difference in performance between healthy controls (M=43.8, SE=2.1) and schizophrenia patients (M=40.3, SE=2.1). There was a significant overall difference in condition (F(1,50)=271.10, p<0.001), indicating that all participants identified more famous faces when presented whole (M=48.4, SE=1.5) than fractured (M=35.8, SE=1.6). The most pertinent finding of this analysis was a significant interaction between task condition and group (F(1,50)=4.47, p<0.05). The pattern of performance on the two conditions was different for the two groups. It appears configural disruption had significantly less of an impact on schizophrenia patients than healthy controls. Schizophrenia patients showed a smaller difference in performance between the fractured and unfractured conditions (difference=10.96) than control participants (difference=14.19) and were thus relatively better at the fractured condition. Performance difference between the two conditions for schizophrenia patients was not significantly correlated with any of the PANSS symptom variables.

Discussion

Control participants relied more on second-order configural information during face recognition, and were thus disadvantaged when this information was disrupted. These findings are consistent with other methods of configural disruption such as inversion. Conversely, schizophrenia patients appeared to utilise different face processing styles compared to control participants. Schizophrenia patients did not appear to utilise configural information to the same degree as the healthy controls, and seemingly relied more on featural information for face recognition. Accordingly, as predicted, schizophrenia patients were less affected when second-order disruption occurred. Considering there was no overall group effect, the pattern of results did not appear indicative of a generalised cognitive deficit that are task or condition specific. This is particularly interesting as research typically indicates schizophrenia patients show an increased performance deficit as task demand increases. This finding contrastingly, actually indicated a decreased performance deficit as task demand increased for schizophrenia patients.

As indicated in section 5.1.8, face processing from a holistic processing viewpoint suggests that faces are viewed not just as multiple feature components but as whole representations. In
addition to the second-order configural disruption, the Fractured Faces Task also altered holistic information, whereby the Gestalt was disturbed. In contrast, the following task investigated holistic face processing while maintaining the second-order configural information as constant.

5.4.4 Complete over Part probe Advantage (CPA) Task

As indicated above in section 5.1.8, some authors have suggested face perception occurs through holistic processes, whereby the individual parts of the face are not explicitly represented. Therefore, the ‘complete over part probe advantage’ (CPA) task developed by Tanaka and Farah (1993) was used to investigate basic whole and part face processing which corresponds to holistic and featural processing. Similar to Tanaka et al. (1998), the task design was altered slightly to minimise long-term memory demands in the current study.

Researchers have argued that healthy upright face perception involves holistic processes whereby a whole ‘Gestalt’ image is formed, thus the following predictions were made relating to performance of control participants:

A. Face recognition would be better in the context of the whole face, than in isolated parts, i.e. revealing a complete over part probe advantage (CPA).

B. Further, this CPA would not be apparent for inverted stimuli as holistic processes are disrupted by inversion.

C. Performance would be better for upright over inverted stimuli, i.e. revealing a FIE.

D. As a consequence of the discussion on feature saliency in section 5.1.2, it was further predicted that performance would be better for stimuli relating to the eyes, followed by the mouth, and lastly the nose. Considering the argument that inversion bears no impact on feature saliency, it was expected that this pattern would remain consistent over both orientations.

In agreement with the argument that schizophrenia patients rely less on top-down, global holistic processes and more on bottom-up fragmented processes, the following predictions were made:
E. Performance would be no different between complete and part stimuli, hence schizophrenia patients would not demonstrate a CPA.

F. Further, there would be less of a difference in performance between inverted and upright stimuli, thus showing a reduced FIE.

G. Considering the inconsistent information regarding feature saliency in schizophrenia, specific predictions on performance were difficult. If predictions were made based on the literature suggesting a similar attentional bias towards the eyes is observable in healthy controls and schizophrenia patients (Leppanen et al., 2008), it was expected the two groups would show the same pattern of feature saliency, i.e. performance would be best for the eyes, followed by the mouth, and then the nose, consistent over orientations. Alternatively, if predictions were made based on the visual scan literature suggesting a restricted scan pattern for facial information (Loughland et al., 2002b) it would be predicted that schizophrenia patients would show consistent performance across features or better performance to less socially relevant areas i.e. the nose.

Method

Stimuli consisted of gray-scaled emotionally neutral faces chosen from the PoFA series (Ekman & Friesen, 1976). Three male and three female faces were selected to make six target faces. For each of these six target faces, a foil face was created by digitally replacing either the eyes nose or mouth of the target face with the corresponding eyes nose or mouth from one of the other six faces (of the same gender). Foils differed from the target by only one feature, i.e. the eyes, nose or mouth. These digital manipulations were performed in the same manner as the Featural task detailed in section 5.4.2. The replacement features did not differ in brightness or contrast to the target faces. Further, they were selected to closely match the iris size and width of the nose and mouth to that of the target face. During stimuli editing, the blurring tool was used to maintain continuity of skin shade. Therefore all face manipulations were subtle, resulting in normal looking faces with careful attempts made to avoid distinctiveness or grotesqueness.

Stimuli were presented as either a whole or as a part, whereby the eyes, nose and mouth sections were presented separately. Therefore each of the six target faces was presented as a whole, and as a part showing the eyes only, showing the nose only and showing the mouth only. Each of
the six target faces had an associated foil face that was presented as a whole differing in eyes, differing in nose and differing in mouth, as well as a part showing the eyes only, showing the nose only and showing the mouth only. Furthermore, all stimuli were presented in both an upright and inverted orientation. All whole face images were 225 x 315 pixels in size, eyes were 200 x 70 pixels, noses were 70 x 65 pixels and mouths were 110 x 50 pixels. An example of the whole and part face stimuli is shown in Figure 14.

![Figure 14. CPA Task Stimuli: Whole (differing eyes) and Part.](image)

Each target face was presented for 3.5 seconds and was then replaced with the same face (in either whole or part form) presented next to a foil face (in either whole or part form). The target face was presented to the right of the foil for half the trials and to the left of the foil for the other half of the trials. A fixation cross (+) appeared on the screen for 500ms in between each trial. Participants were instructed to respond as quickly yet as accurately as possible to indicate which one of the two faces was the target face. Participants responded by pressing either a left or right button to indicate which face they believed to be the target face. They had eight seconds to respond and as soon as they did so the task progressed to the next trial.

After reading the instructions, participants completed eight practice trials involving different stimuli to those in the test phase. The test phase included six upright and six inverted stimuli for the whole and part conditions for each of the three features, eyes, nose and mouth. Thus participants completed 72 randomised trials.
Results

Mixed between-within groups ANOVA was used to examine task performance for the schizophrenia patients and controls. The within-factor variables included orientation (upright vs. inverted), condition (whole face vs. part) and feature (eyes vs. nose vs. mouth) and the between-factors variable included group (schizophrenia vs. control). Post-hoc paired samples t-tests were performed to investigate any significant interactions. Preliminary checks were conducted to assess the assumptions of normality, homogeneity of variance, and homogeneity of intercorrelations. There were some issues of normality particularly for the accuracy data. However, considering the groups were equal in size, ANOVA is robust to violations of this assumption. There were no apparent ceiling or floor effects. One schizophrenia patient did not complete the task. The means and standard deviations of each group are shown in Table 15.

Table 15. Schizophrenia and Healthy Control Performance on the CPA Task

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia (n=28)</th>
<th>Control (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accuracy (% correct)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upright Eyes</td>
<td>79.17 (20.60)</td>
<td>91.95 (11.46)</td>
</tr>
<tr>
<td>Nose</td>
<td>57.14 (18.94)</td>
<td>66.09 (21.12)</td>
</tr>
<tr>
<td>Mouth</td>
<td>64.29 (21.62)</td>
<td>76.44 (18.10)</td>
</tr>
<tr>
<td>Inverted Eyes</td>
<td>60.71 (20.89)</td>
<td>77.01 (20.61)</td>
</tr>
<tr>
<td>Nose</td>
<td>54.76 (18.06)</td>
<td>57.47 (17.01)</td>
</tr>
<tr>
<td>Mouth</td>
<td>55.95 (19.36)</td>
<td>60.35 (16.31)</td>
</tr>
<tr>
<td>Part</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upright Eyes</td>
<td>69.05 (19.62)</td>
<td>82.18 (16.02)</td>
</tr>
<tr>
<td>Nose</td>
<td>64.88 (14.59)</td>
<td>63.79 (16.71)</td>
</tr>
<tr>
<td>Mouth</td>
<td>53.57 (20.96)</td>
<td>71.26 (19.87)</td>
</tr>
<tr>
<td>Inverted Eyes</td>
<td>59.52 (18.94)</td>
<td>69.54 (17.29)</td>
</tr>
<tr>
<td>Nose</td>
<td>60.12 (17.18)</td>
<td>60.92 (24.10)</td>
</tr>
<tr>
<td>Mouth</td>
<td>58.33 (20.03)</td>
<td>67.82 (15.39)</td>
</tr>
<tr>
<td><strong>Response Time (ms)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upright Eyes</td>
<td>2158.58 (1073.74)</td>
<td>1786.03 (498.75)</td>
</tr>
<tr>
<td>Nose</td>
<td>2170.46 (1007.93)</td>
<td>2570.05 (873.17)</td>
</tr>
<tr>
<td>Mouth</td>
<td>2182.42 (907.94)</td>
<td>2094.33 (641.91)</td>
</tr>
<tr>
<td>Inverted Eyes</td>
<td>2113.00 (973.55)</td>
<td>2288.83 (690.11)</td>
</tr>
<tr>
<td>Nose</td>
<td>2295.07 (1041.92)</td>
<td>2624.18 (863.65)</td>
</tr>
<tr>
<td>Mouth</td>
<td>2285.10 (1052.84)</td>
<td>2536.42 (689.14)</td>
</tr>
<tr>
<td>Part</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upright Eyes</td>
<td>1857.12 (692.59)</td>
<td>1861.34 (523.79)</td>
</tr>
<tr>
<td>Nose</td>
<td>2271.54 (915.44)</td>
<td>2130.54 (699.64)</td>
</tr>
<tr>
<td>Mouth</td>
<td>2411.50 (1243.43)</td>
<td>2090.33 (600.80)</td>
</tr>
<tr>
<td>Inverted Eyes</td>
<td>2069.80 (892.76)</td>
<td>2029.37 (602.36)</td>
</tr>
<tr>
<td>Nose</td>
<td>1964.36 (1016.57)</td>
<td>2176.68 (672.09)</td>
</tr>
<tr>
<td>Mouth</td>
<td>2099.85 (936.44)</td>
<td>2139.08 (546.29)</td>
</tr>
</tbody>
</table>
A summary of the following main effects and interactions is presented in Appendix 4.

Main Effects
Overall, controls performed more accurately (M=70.4, SE=1.4) than schizophrenia patients (M=61.5, SE=1.4) (F(1,55)=19.70, p<0.001). There were however, no significant differences in average response time between controls (M=2193.8, SE=97.3) and patients (M=2180.9, SE=99.0).

Overall, all participants were more accurate for the upright faces (M=70.0, SE=1.2) compared to the inverted faces (M=61.9, SE=1.2; F(1,55)=38.41, p<0.001). However, there were no significant differences in response times for the upright faces (M=2150.0, SE=70.8) compared to the inverted faces (M=2224.7, SE=79.6).

There was no significant difference in accuracy between the part condition (M=65.1, SE=1.3) compared to the whole face condition (M=66.8, SE=1.1). However, the response time data indicates participants displayed quicker response times for the part condition (M=2095.8, SE=61.3) compared to the whole face condition (M=2278.9, SE=89.9; F(1,53)=7.61, p<0.01).

Furthermore for the comparison between the different features of the face participants showed a difference in accuracy (F(2,54)=28.69, p<0.001) and response time (F(2,52)=9.03, p<0.001). Accuracy was significantly higher for the trials involving eyes (M=73.6, SE=1.5) compared to mouths (t(56)=5.31, p<0.001; M=63.5, SE=1.7) as well as noses (t(56)=6.86, p<0.001; M=60.6, SE=1.3), there was no significant difference in accuracy between mouths and noses. Similarly, response times were significantly faster for the trials involving eyes (M=2036.1, SE=88.9) compared to mouths (t(56)=2.82, p<0.01; M=2250.8, SE=70.3) as well as noses (t(56)=4.38, p<0.001; M=2275.2, SE=75.5), and there was no significant difference in response time between mouths and noses.

Interactions
The analysis revealed no significant interaction between orientation x group or condition x group for either accuracy or response time. There were no significant three-way interactions for either accuracy or response time between orientation x condition x group, orientation x feature x group, condition x feature x group or orientation x condition x feature.
Analysis revealed a significant interaction between feature x group for accuracy ($F(2,54)=4.20, p<0.05$) however not for response time. Schizophrenia patients and controls differed in accuracy for trials involving eyes ($F(1,55)=19.74, p<0.001$; schizophrenia $M=67.11, SE=2.38$; controls $M=80.17, SE=1.75$) and mouths ($F(1,55)=10.89, p<0.01$; schizophrenia $M=58.04, SE=2.49$; controls $M=68.97, SD=2.19$), however not noses. While controls performance was best for eyes, followed by mouths and then nose stimuli; schizophrenia performance was best for eyes followed by nose and then mouth stimuli. There was no significant group x feature x orientation interaction indicating this pattern of performance was consistent across upright and inverted orientations.

Analysis revealed a significant interaction between orientation x condition for both accuracy ($F(1,55)=7.63, p<0.01$) and response time ($F(1,53)=7.10, p<0.05$). Participants were significantly more accurate for the whole face condition compared to the part condition when the stimuli were presented upright ($t(56)=2.86, p<0.01$), however there was no difference between whole and part condition when the stimuli were inverted. Furthermore, a significant FIE (reduced accuracy to inverted stimuli) was apparent for both whole faces ($t(56)=6.40, p<0.001$) and parts ($t(56)=2.69, p<0.01$). The response time analysis indicated that there was no difference between the whole and part condition when stimuli were upright, however when stimuli were inverted participants were slower to respond to the whole faces than the parts ($t(56)=3.67, p<0.01$). Furthermore, there was a significant FIE (slower response time to inverted stimuli) for the whole face condition ($t(56)=-3.12, p<0.01$), however not for the part condition.

Furthermore, analysis revealed a significant interaction between orientation x feature for both accuracy ($F(2,54)=6.43, p<0.01$) and response time ($F(2,52)=3.22, p<0.05$). Participants demonstrated a FIE for stimuli discriminating on the eyes ($t(56)=6.86, p<0.001$) and mouth ($t(56)=2.54, p<0.05$), however not the nose feature. Furthermore, the pattern of performance with featural change was the same for both upright and inverted stimuli i.e. performance was best for discriminating the eyes, followed by mouth, and lastly nose. Response time analysis also indicated a FIE for the eyes ($t(56)=-3.73, p<0.001$), however not for the mouth or nose features. Furthermore, participants responded fastest for the trials involving eyes followed by mouths and then noses for both upright and inverted orientations.

There was a significant interaction between condition x feature for accuracy ($F(2,54)=4.32, p<0.05$), however not for response time. Participants were more accurate for whole faces
compared to parts for trials involving eyes ($t(56)=3.08, p<0.01$); however there was no difference between the whole and part condition for noses or mouths. Furthermore, the pattern of performance with featural change was the same for both whole and part conditions i.e. performance was best for discriminating the eyes, followed by mouth and lastly nose.

There was a significant four-way interaction between orientation x condition x feature x group for response time ($F(2,52)=3.28, p<0.05$), however not for accuracy. This interaction was explored via a series of paired-samples t-tests with Bonferroni correction of $p<0.0083$. It was revealed for the whole face condition, schizophrenia patients showed no significant difference in response time between upright and inverted orientations for eyes, nose or mouth stimuli, thus revealing no FIE. In comparison, controls showed longer response times to inverted over upright orientations for eyes ($t(28)=5.34, p<0.0083$, and mouth stimuli ($t(28)=3.91, p<0.0083$), however not for nose stimuli. For the part face condition, the schizophrenia patients and controls showed no significant difference in response time between upright and inverted orientations for eyes, nose or mouth stimuli.

Of main interest from this task was the interaction between orientation x condition x group, as indicated above, this did not reach significance for either accuracy or response time, however as the 4-way interaction was significant, exploratory analysis was performed to investigate the relationship between orientation and condition for the groups separately. For accuracy performance, analysis indicated the interaction between orientation x condition approached significance for controls ($F(1,28)=3.60, p=0.068$) and schizophrenia patients ($F(1,27)=4.13, p=0.052$), the results are displayed in Figure 15. Control participants showed greater accuracy for whole faces compared to parts when stimuli were presented upright ($t(28)=2.30, p<0.05$), however, no difference in accuracy when stimuli were inverted. In comparison, schizophrenia patients showed no difference in accuracy between whole faces and parts when stimuli were presented upright or inverted.
For response time performance, the analysis indicated the interaction between orientation x condition was significant for control participants ($F(1,27)=8.04$, $p<0.01$) but not schizophrenia patients. Control participants demonstrated no difference in response time to whole faces compared to parts when stimuli were upright, however, were slower to respond to whole faces than parts when stimuli were inverted ($t(28)=3.48$, $p<0.01$). Furthermore, controls showed a
FIE for whole faces ($t(28)=-4.60, p<0.001$), however not for parts. For schizophrenia patients there was no difference in response time for the whole compared to part condition for upright or inverted faces, nor was there any FIE apparent.

For schizophrenia patients, age was significantly negatively correlated with accuracy performance for upright part stimuli pertaining to the mouth ($r=-.53, p<0.017$). Furthermore, PANSS Positive Scores were significantly positively correlated with response time to upright part stimuli pertaining to the nose. There were no other significant correlations between task performance and demographic or clinical characteristics for either controls or schizophrenia patients.

*Discussion*

The hypotheses detailed above received support from the data. The following findings confirm the predicted pattern of performance for control participants, indicating the tasks appropriately assessed featural and holistic face processing.

A. Control participants showed greater accuracy for whole faces than parts for upright stimuli, thus revealing a CPA.

B. There was no difference in accuracy between whole faces and parts for inverted stimuli, thus indicating no CPA.

C. Overall controls performed more accurately and responded quicker to upright than inverted faces, thus showing a FIE.

D. As predicted, performance of control participants was better for stimuli relating to the eyes, followed by the mouth, and lastly the nose. As expected, this was consistent over both upright and inverted orientations.

These results show that healthy controls do process upright faces more efficiently than inverted faces; however, face parts are not as vulnerable to this effect as whole faces. Therefore, these results confirm claims that face inversion disrupts holistic processing. These results are consistent with previous findings using a similar task design that revealed comparable accuracy performance (Farah et al., 1995a; Tanaka & Farah, 1993; Tanaka & Sengco, 1997). Furthermore,
the pattern of performance for the current adult control participants was surprisingly similar to that of healthy developing 11 year-old children (Joseph & Tanaka, 2003).

The following findings supported the notion that schizophrenia patients may show deficits in holistic face processing.

E. Schizophrenia patients did not show a difference in performance between whole faces and parts, in either upright or inverted orientations (i.e. no CPA).

F. Schizophrenia patients did not show a difference in response time for upright and inverted faces (i.e. no FIE).

G. The prediction that schizophrenia patients would show the same pattern of feature saliency as controls was partially supported. Schizophrenia performance was best for the eyes, followed by the nose, and then the mouth. This is consistent with Leppanen et al. (2008) who indicated that schizophrenia patients show the same attentional bias to the eye region as controls. With regards to the visual scanpath literature, the results do support the finding that schizophrenia patients show an avoidance of the lower regions of the face i.e. the mouth, and tend to focus on more socially irrelevant areas i.e. the nose. This is observable in Figure 5 presented in Chapter 4.

These results demonstrate that schizophrenia patients do not process facial information in the same way as controls. In particular, patients were not as vulnerable to inversion effects, particularly reflected by the response time data. Furthermore, schizophrenia patients did not appear to benefit from holistic processing strategies evidenced by a lack of CPA. These results are in line with the argument that schizophrenia patients do not perceptually integrate visual components to form a unified whole, and instead rely on piecemeal strategies for perception (Place & Gilmore, 1980; Wells & Leventhal, 1984).

Although this particular task has not been used in a schizophrenia sample before, it has been used in developmental investigations in a sample of children with autism (Joseph & Tanaka, 2003). Unlike the schizophrenia patients, the children with autism did reveal a CPA (advantage for whole over part faces), however only for trials relating to the mouth, and not for the eyes. The researchers argued that children with autism can show typical holistic processing for some features but not others. Individuals with autism tend to exhibit particular preference for viewing
the mouth over other regions of the face (Klin et al., 2002). Furthermore, they also demonstrate a distinct deficit in reading information from the eyes (Baron-Cohen et al., 1997b). Therefore children with autism do not show a generalised deficit in holistic processing, rather a specific deficit which may be related to a bias towards some features, i.e. the mouth, or away from others, i.e. the eyes. The schizophrenia patients in comparison demonstrated no CPA, thus suggesting a generalised deficit in holistic processing.

Although there was some indication of a relationship between CPA performance and age as well as PANSS positive ratings for schizophrenia patients; these correlations were only apparent for one out of the twelve CPA variables. Thus the implications of these findings remain tenuous.

The stimuli used with the CPA task assessed holistic processes, however also contained featural, first-order configural and second-order configural information. Therefore, the subsequent task was developed to assess pure holistic processes whereby featural information was minimised.

5.4.5 Mooney Faces Task

This task has been used previously to investigate holistic face processing (Latinus & Taylor, 2005; Moscovitch et al., 1997). Mooney faces do not contain specific featural information, and thus cannot be initially processed via first or second-order configural processes as there are no clear features to identify. Thus without observable features, processing a set of eyes above the nose and mouth i.e. first-order, or the specific relations between these features, i.e. second-order, is not possible. Therefore, to detect a face, the ‘gaps’ must be ‘filled in’ to visually complete the object. Only once this Gestalt is established do the features become apparent. This task relies on both perceptual closure and face discrimination processes (Wasserstein et al, 2004).

Considering the role of holistic information in face perception, the following hypotheses were made relating to control participants:

A. Mooney faces rely on holistic processing, therefore it was hypothesised that healthy controls would respond more accurately and faster to upright than inverted Mooney faces as the holistic information would be lost upon stimulus inversion, i.e. a FIE.
As with the CPA task, it was expected that schizophrenia patients would rely less on top-down, global holistic processes and more on bottom-up fragmented processes. Therefore the following predictions were made:

B. Schizophrenia patients would demonstrate a generalised impaired performance on the task due to a reduced ability to process holistic information.

C. Furthermore, schizophrenia patients would show less of a difference in performance between inverted and upright faces, thus showing a reduced FIE.

Method

Stimuli were constructed using 40 Mooney faces (Mooney, 1957). Mooney faces involve black and white images constructed of patches of intense flat light and shadow. Based on the design of Latinus and Taylor (2005), each face was either presented normally (‘face’ condition) or scrambled (‘non-face’ condition). The non-face stimuli had been digitally edited by capturing and moving the ‘patches’ of black and white, this scrambling disrupted the representation of a face. An example of the face and non-face Mooney images are shown in see Figure 16. Images were 510 x 650 pixels in size.

![Figure 16. Mooney Face Task Stimuli](image)

Each stimuli was presented in the centre of the screen for 3000ms seconds followed by a fixation cross (+) for 500ms. Participants were told they were going to see a black and white picture on the screen and they were to decide if the picture was a real face or not. Via a two-button press participants were instructed to respond as quickly and accurately as possible to indicate the picture was either a ‘face’ or a ‘non-face’. A piece of paper was placed in front of the participant
to remind them which button was which. After reading the instructions, participants completed three practice trials. Thereafter, each of the 40 faces and 40 non-faces were randomly presented in an upright and inverted orientation, hence there were 160 experimental trials in total.

**Results**

Mixed between-within groups ANOVA was used to examine task performance for the schizophrenia patients and controls. Within-factor variables included condition (face vs. non-face) and orientation (upright vs. inverted), the between-factors variable included group (schizophrenia vs. control). Preliminary checks were conducted to assess the assumptions of normality, homogeneity of variance, and homogeneity of intercorrelations. The accuracy and response times for control participants was normally distributed, however, was not for the schizophrenia participants. Levene’s test and Box’s M test confirmed no violations of the homogeneity of variance and homogeneity of intercorrelations assumptions. There was no apparent floor or ceiling effect. One schizophrenia patient did not complete this task. The means and standard deviations of each group are shown in Table 16.

| Table 16. Schizophrenia and Healthy Control Performance on the Mooney Faces Task |
|-----------------------------------|------------------|------------------|
|                                   | Schizophrenia \(n=28\) | Control \(n=29\) |
| Accuracy (% correct)              |                  |                  |
| **Face**                          |                  |                  |
| Upright                           | 59.73 (20.35)    | 64.31 (19.72)    |
| Inverted                          | 26.70 (16.93)    | 31.29 (19.24)    |
| **Non-Face**                      |                  |                  |
| Upright                           | 81.25 (13.67)    | 80.60 (12.06)    |
| Inverted                          | 82.50 (14.34)    | 81.03 (14.46)    |
| Response Time (ms)                |                  |                  |
| **Face**                          |                  |                  |
| Upright                           | 1067.97 (314.61) | 1123.86 (277.20) |
| Inverted                          | 1315.02 (378.16) | 1516.18 (331.91) |
| **Non-Face**                      |                  |                  |
| Upright                           | 1129.70 (362.32) | 1566.69 (354.01) |
| Inverted                          | 1125.99 (402.31) | 1544.13 (373.05) |

A summary of the following main effects and interactions is presented in Appendix 5.

**Main Effects**

Overall, there was no significant difference in accuracy between controls \(M=64.3, SE=1.7\) and schizophrenia patients \(M=62.5, SE=1.7\). Interestingly however, response times were significantly faster for schizophrenia patients \(M=1159.7, SE=57.5\) than controls \(M=1437.7, SE=55.4; F(1,54)=12.13, p<0.01\).
Participants responded more accurately to the non-face condition ($M=81.3$, $SE=1.7$) than the face condition ($M=45.5$, $SE=2.3$) ($F(1,55)=120.72$, $p<0.001$). However, participants responded quicker to the face condition ($M=1255.8$, $SE=40.1$) than the non-face condition ($M=1341.6$, $SE=49.1$) ($F(1,55)=4.40$, $p<0.05$).

Participants were more accurate for upright faces ($M=71.5$, $SE=1.5$) than inverted faces ($M=55.4$, $SE=1.2$) ($F(1,55)=211.80$, $p<0.001$). Correspondingly, participants were quicker to respond to upright faces ($M=1222.1$, $SE=39.2$) than inverted faces ($M=1375.3$, $SE=43.1$) ($F(1,55)=58.1$, $p<0.001$).

**Interactions**

There was a significant interaction between group and condition for the response time data ($F(1,54)=13.34$, $p<0.01$), but not for accuracy. Post-hoc paired samples t-tests revealed that the controls responded faster for faces ($M=1320.0$, $SE=55.8$) than non-faces ($M=1555.4$, $SE=68.2$; $t(28)=-3.42$, $p<0.01$), however there was no significant difference between faces ($M=1191.5$, $SE=57.8$) and non-faces ($M=1127.8$, $SE=70.7$) for schizophrenia patients. Furthermore, independent-samples t-tests revealed that the groups did not differ in response time for faces, however, schizophrenia patients were faster to respond than controls for non-faces ($t(55)=4.23$, $p<0.001$).

There were no significant interactions between group and orientation for either accuracy or response time. There was however, a significant interaction between condition and orientation for both accuracy ($F(1,55)=160.63$, $p<0.001$) and response time ($F(1,54)=82.43$, $p<0.001$). Paired samples t-tests revealed participants were more accurate for upright non-faces ($M=80.9$, $SE=1.7$) than upright faces ($M=62.0$, $SE=2.7$; $t(56)=-5.63$, $p<0.001$), and similarly were more accurate for inverted non-faces ($M=81.8$, $SE=1.9$) than inverted faces ($M=29.0$, $SE=2.4$; $t(56)=-14.4$, $p<0.001$). In contrast the response time data indicated participants were faster to respond to upright faces ($M=1095.9$, $SE=39.6$) than upright non-faces ($M=1348.2$, $SE=47.9$; $t(56)=-5.58$, $p<0.001$), however there was no difference in between inverted faces ($M=1415.6$, $SE=47.5$) and inverted non-faces ($M=1335.1$, $SE=51.8$). Furthermore, a significant FIE was observed as participants were more accurate ($t(56)=14.83$, $p<0.001$) and faster to respond ($t(56)=-9.08$, $p<0.001$) to upright faces than inverted faces. There was no significant difference in accuracy or response time between upright and inverted non-faces, which is logical as the non-faces were
random patches of black and white which should carry no meaning with respect to orientation. Thus the non-faces should not be processed differently when presented upright or inverted.

There was a significant group x condition x orientation interaction for response time ($F(1,54)=5.01, p<0.05$), but not for accuracy. As indicated in Figure 17, both groups showed a response time FIE for faces (control, $t(28)=-7.77, p<0.001$; schizophrenia, $t(28)=-5.33, p<0.001$), but not for non-faces. Furthermore, paired samples t-tests indicated controls responded quicker for upright faces than upright non-faces ($t(28)=-6.98, p<0.001$), however no difference was observable when stimuli were inverted. In comparison, schizophrenia patients responded quicker for inverted non-faces than inverted faces ($t(26)=3.79, p<0.01$), however this difference was not apparent when stimuli were upright.
Figure 17. Mooney Faces Task Performance – Response Time

For control participants, age was significantly correlated with accuracy performance for upright Mooney faces ($r=-.72$, $p<0.017$), and response time for upright Mooney faces ($r=.52$, $p<0.017$), upright non-faces ($r=.52$, $p<0.017$), and inverted non-faces ($r=.55$, $p<0.017$). There were no other significant correlations between task performance and demographic or clinical characteristics for either controls or schizophrenia patients.
Discussion

The hypotheses detailed above received partial support from the data. The following findings confirm the predicted pattern of performance for control participants, indicating the tasks appropriately assessed holistic face processing.

A. Healthy control participants responded faster to upright than inverted Mooney faces, thus demonstrating a FIE. Thus as predicted, it appears holistic information was lost upon face inversion.

This pattern of results was consistent with other studies (Batty et al., 2009a; George et al., 2005; Latinus & Taylor, 2005). Furthermore, these behavioural findings were in line with studies indicating Mooney faces activate the FFA (Kanwisher et al., 1998) and illicit the face-specific N170 (Latinus & Taylor, 2005), however only when presented in an upright orientation and not in an inverted orientation.

The performance demonstrated by the schizophrenia participants did not provide support for hypotheses detailed above.

B. Schizophrenia patients did not demonstrate a generalised impairment. In fact, schizophrenia patients actually showed overall faster response times compared to controls on this task. Upon looking at the data in more detail, it was apparent that there was no response time difference between the groups for face stimuli; however, schizophrenia patients were particularly quick to respond for non-face stimuli. The fact that schizophrenia patients were quicker to respond to inverted non-faces over inverted faces is intriguing. Considering face inversion is thought to disrupt holistic processing, inverted Mooney faces should theoretically not resemble faces at all. Therefore the difference in response time for inverted faces and non-faces shown by schizophrenia patients is difficult to interpret. The most likely explanation for the results of this task relates to the possible response bias. It appeared as though both groups had more of a tendency to respond ‘non-face’ over ‘face’, however this may have been more apparent in the schizophrenia sample. This would explain the faster responses made by schizophrenia patients for non-face trials, particularly for those inverted.
C. Furthermore, against predictions, schizophrenia patients did show a difference in performance between inverted and upright faces, and thus demonstrated a typical FIE. This is inconsistent with the other face processing tasks described above.

No other study has used the same test design to assess schizophrenia patients on Mooney face discrimination. As indicated this task appeared to invoke a response bias thus the results are interpreted with reservation. Performance accuracy was below chance for inverted faces, thus, although the results suggest holistic processing in intact in schizophrenia, such conclusions are definitely not made with certainty.

5.4.6 Results Summary

To summarise, a simplification of the performance of the schizophrenia patients can be observed in Table 17. This will be subsequently discussed in greater detail below.

<table>
<thead>
<tr>
<th>Table 17. Summary of Schizophrenia Performance</th>
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<tbody>
<tr>
<td>Task</td>
</tr>
<tr>
<td>Scrambled Faces Task</td>
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<tr>
<td>Featural Task</td>
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<tr>
<td>Spacing Task</td>
</tr>
<tr>
<td>Fractured Faces Task</td>
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<tr>
<td>CPA Task</td>
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<tr>
<td>Mooney Faces Task</td>
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</table>

Some researchers have indicated face processing in schizophrenia is related to clinical characteristics such as delusions (Phillips & David, 1995), negative symptomatology (Martin et al., 2005), or general symptom severity (Penn et al., 2000; Sachs et al., 2004). In contrast, the current data indicated there were no consistent correlations between any of the face processing tasks and demographic variables such as age, education and IQ. Nor were there any correlations between task performance and clinical characteristics such as medication, age at illness onset, illness duration, or PANSS ratings. This is in line with others who have also reported no consistent symptom correlations with face processing (Addington & Addington, 1998; Chen et al., 2008; Kucharska-Pietura et al., 2005).
5.5 General Discussion

The six tasks described above each assessed a particular aspect of face processing. The following discussion will begin with a brief outline of how the performance on these tasks can contribute to an understanding of healthy face processing. Thereafter a model for healthy face processing is proposed. A discussion on the specific impairment shown by schizophrenia patients, in some, but not all aspects, of this model of face processing will then be covered. The factors that potentially contribute to impaired face processing and the implications of such deficits are then addressed.

5.5.1 Healthy Face Processing

The Scrambled Faces task assessed first-order configural processing. Considering the high accuracy scores and fast response times to this task, it is clear healthy controls were efficiently able to process disruption in first-order configuration, and were easily able to distinguish faces from non-faces. Evidently, first-order configural information is basic yet crucial for face perception. A face with distorted first-order information is simply not recognised as a face.

The Featural task assessed how a change in featural information impacted on facial discrimination. Healthy controls were capable of perceiving featural change. In comparison, the Spacing task assessed how a change in second-order configural information impacted on facial discrimination. Although still competent, controls were less capable at discriminating faces based on second-order configural information than featural information, suggesting featural change is more palpable. The effects of face inversion within these tasks were particularly interesting. The difference between upright and inverted face discrimination i.e. FIE, was greater for the Spacing task than the Featural task. This finding confirms that separate mechanisms are used for featural and configural information processing and that inversion bears little impact of featural face perception. However, second-order face perception is particularly vulnerable to inversion.

The Fractured Faces task revealed that second-order configural disruption not only impacts on face discrimination, but also face recognition. Similar to face inversion, the spreading apart of facial features also disrupted second-order configural information, and thus impaired performance. Despite first-order and featural information remaining constant, controls found
recognition of famous faces particularly difficult. This highlights the importance of second-order configural information for face recognition.

The CPA task demonstrated that for controls, recognition of upright faces was better when the whole face was available than when only the parts of the face were present, thus revealing a complete-over-part probe advantage. This was seemingly due to a reliance on holistic processing as the integration of the facial features aided in recognition. When stimuli were inverted, the advantage of having the information from the whole face was lost and performance was similar for whole faces and parts of the faces. This suggests holistic processing was disrupted by inversion. Interestingly, performance on this task was better for some features over others. Specifically, controls performed best for stimuli pertaining to the eyes, followed by mouth and then nose. This was constant over orientations, which, as indicated by the Featural task fits with the argument that featural processing is not greatly impacted upon by inversion.

The Mooney Faces task further investigated holistic processing, and revealed that controls were faster to respond to faces than non-faces when presented upright suggesting a preference for facial information. This was not apparent however when stimuli were inverted. As inversion disrupts holistic information, inverted Mooney faces appear to be processed more like non-facial stimuli. Furthermore, the use of holistic processing for face perception was evidenced by an apparent inversion effect for faces but not non-faces. This is logical as non-faces are not mono-oriented, and are thus not vulnerable to inversion like facial stimuli are.

In summary, these tasks demonstrated inversion bears little impact on featural processing yet disrupts both second-order and holistic processing. These results are in line with the dual-mode hypothesis (Bartlett & Searcy, 1993), indicating that upright and inverted faces require different visual processes. The results further illustrate the importance, and role, that different processing strategies play in face perception. Based on the review by Maurer et al. (2002), the current body of work aimed to theoretically combine these different processing strategies together to propose a basic, integrated model for healthy face perception.

5.5.2 A Model of Healthy Face Processing

As indicated in Figure 18, healthy face perception relies on featural and configural information. The specific information regarding the facial features, such as size and shape, involves featural
processing strategies. The way in which these features relate to one another involves configural processing strategies. This ranges from basic first-order information, such as the general configuration common to all faces, to the fine detail relating to the spacing and distance between features as well as the overall Gestalt of the face. The results above indicated these processes occur at the encoding stage of face perception rather than storage retrieval as the tasks contained relatively little memory demand.

![Face Processing Diagram]

This model is simplified to provide information on the structural encoding of facial information and thus relates only to the more basic aspects of face perception. The ability to perceive and recognise a face clearly involves other processes not included in the model above. For example, featural and configural processing rely on the preceding basic visual mechanisms that occur in the primary and secondary visual cortex. For example, basic perceptual processing of information such as colour, motion, depth and contour are important in the observation of facial stimuli. Furthermore, subsequent higher order processes occur once a facial stimulus is established. For example, semantic memory retrieval facilitates familiarity perception by incorporating previously stored information about a person. Thereafter subjective judgement is made about the individual face based on the relevant cognitive schema previously stored.
5.5.3 Face Processing in Schizophrenia

The following section of this chapter will go on to use the model illustrated in Figure 18 to explore face processing in schizophrenia. As indicated above, each task in the current chapter tested a different aspect of the proposed model. Consequently, by inspecting the performance demonstrated by schizophrenia patients on these tasks, it is possible to assess the aspects of face perception that are intact or aberrant.

Featural Processing in Schizophrenia

Results from the Featural task indicated that schizophrenia patients showed an overall impairment evidenced by accuracy, however not response time. Therefore, for schizophrenia patients, facial discrimination was impacted by a change in featural information. Although there was an overall impairment in featural processing, this was not as great as the impairment in second-order configural processing, evidenced by the Spacing task.

First-order Configural Processing in Schizophrenia

As indicated by the Scrambled Faces Task, schizophrenia patients did not show a difference in recognition of faces over scrambled faces, whereby first-order configural information had been disrupted. After attentional capacity was controlled for, schizophrenia patients also did not exhibit a performance deficit compared to controls. Evidently, schizophrenia patients were able to distinguish facial stimuli that differed in first-order configural information. Therefore, schizophrenia patients appear to utilise first-order configural information for face perception.

Second-order Configural Processing in Schizophrenia

An overall impairment on the Spacing task indicated a change in second-order configural information impacted facial discrimination for schizophrenia patients. The effect of face inversion on response time for this task was particularly interesting. Schizophrenia patients did not demonstrate a typical FIE, i.e. faster responses for upright over inverted faces. Therefore, a reduced or absent FIE suggests configural disruption has less of an impact on discrimination. Thus, schizophrenia patients appeared to rely less on configural information for face discrimination. This finding was further evidenced by the Fractured Faces task which also
revealed that second-order configural disruption (similar to inversion), had less of an impact on face recognition for schizophrenia patients. The important implication of these findings was that configural disruption, via methods of inversion and fracturing, resulted in less of a relative performance deficit for schizophrenia patients compared to controls. These tasks were designed to show how a disruption of normal, unimpaired processing strategies can reveal a performance deficit. However, when abnormal, impaired processing strategies are in place to begin with, performance is not as affected. These tasks highlight that schizophrenia patients do not utilise typical processing strategies, and are thus not as relatively impaired in task performance.

**Holistic Processing in Schizophrenia**

As with the Spacing task, the CPA task also demonstrated that in schizophrenia patients, response times did not differ when faces were presented upright or inverted, thus failing to show a FIE. Furthermore, recognition of faces was no different when the whole face was available compared to when only the parts of the face were present, thus no CPA was observable. This indicates that schizophrenia patients did not appear to rely on holistic processing strategies for face recognition. Further investigation into holistic processing via the Mooney Faces task was not consistent with these findings however. Schizophrenia patients did not show impairment on Mooney face recognition which required visual closure using holistic processing strategies. The results from this task, however, were interpreted with caution due to potential task design limitations.

**Feature Saliency**

As discussed above in section 5.1.2, previous literature has detailed a hierarchy of the relative importance of each feature type, indicating the eyes tend to be more important than the mouth and nose (Davies et al., 1977; McKelvie, 1976). Interestingly, performance of schizophrenia patients on the CPA task was better for some features over others. Specifically, performance was best for stimuli pertaining to the eyes, followed by the nose and then the mouth. Similar to controls, this was constant over orientations. This is in line with the argument that featural processing is not greatly impacted upon by inversion and featural processing is intact in schizophrenia. The difference between groups on the nose and mouth regions may be related to the visual scan literature indicating restricted scanpath to lower regions of the face and a tendency to focus on more socially irrelevant regions such as the nose.
Summary

As summarised below in Figure 19, these tasks demonstrated that schizophrenia patients show intact featural and first-order processing, yet disturbed second-order and potentially holistic processing. These results are in line with previous studies indicating configural processing may be impaired in schizophrenia (Baudouin et al., 2008; Chen et al., 2008; Shin et al., 2008).

Some authors argue that face perception deficits in schizophrenia are due to a generalised deficit, however, the current work suggests the deficits are relatively specific to particular processing strategies. It is proposed that schizophrenia patients are not entirely impaired in configural processing. Rather, patients may use both featural and configural strategies, however, rely more on featural strategies. This is partially in line with the hierarchical theory of autism; whereby individuals with autism are thought to use both global and local strategies for perception, however, do not have a hierarchical selection process or preferential system for selecting global or local processing (Mottron et al., 2003).

The question remains, why would schizophrenia patients have less of a tendency towards configural processing? As discussed in section 5.1.6, configural processing tends to increase with the level of expertise the individual has with a particular stimulus class. As humans are
particularly familiar with other human faces, an expertise develops with age, resulting in sensitivity to configural information. This expertise theory may to some degree elucidate the configural face processing deficits shown by schizophrenia patients. As indicated in the previous chapter, schizophrenia patients show abnormal visual scanning patterns for facial stimuli (Loughland et al., 2002b). The age at which such abnormal visual scanning occurs has not been established. It is possible however, that atypical scanning early in life may lead to a particular avoidance of facial information. Furthermore, schizophrenia patients typically experience social isolation, particularly when they first begin to experience psychotic symptoms during adolescence. This teenage period is a crucial time for social development and socialising with peers, yet unfortunately a time when schizophrenia patients characteristically withdraw socially. Consequential social isolation, in addition to the abnormal visual scan pattern for faces; may diminish the potential to develop a typical level of expertise for facial information. Therefore, schizophrenia patients may show less expertise for facial stimuli, resulting in less sensitivity to configural information. This expertise theory has been related to the face processing deficits observable in autism (Pierce et al., 2001). Although the level of expertise with faces is considered worse for autism than schizophrenia, any decrease in experience may generate a decrease in configural processing ability.

Another issue that may contribute to an understanding of why schizophrenia patients show problems with configural processing relates to a lateralisation hypothesis. As discussed in section 5.1.7, configural processing is considered a right hemisphere dominant function, whereas featural processing is thought to be a left hemisphere dominant function (Bourne et al., 2008). This is consistent with the perceptual organisation literature that indicates Gestalt processing, i.e. the tendency to perceive a whole, is also a right hemisphere dominant function. Schizophrenia patients show problems in both configural face processing, as shown in the current chapter, as well as Gestalt processing (John & Hemsley, 1992; Place & Gilmore, 1980; Silverstein et al., 1996). As suggested by previous authors (Cutting, 1985; Venables, 1984), schizophrenia patients may have some fundamental right-hemisphere underactivity resulting in an overtaxed left hemisphere. Such a dysfunction may result in impaired configural and holistic processing. Others have suggested that a divergence from the typical left hemisphere dominance for language increases the risk of symptoms such as hallucinations and delusions (Crow, 1997). Furthermore, this lack of hemispheric specialisation is key to the aetiology of schizophrenia. Future investigations could explore the notion that a deficit in configural processing may be related to hemispheric dysfunction in schizophrenia.
The suggestions postulated here represent the beginning of the journey to understanding configural processing in schizophrenia. While the research on configural face processing in schizophrenia is growing, the published works until now fail to cross-reference one another and there is yet to be a review integrating findings together. Thus, as the focus on social cognition in schizophrenia continues to increase, more work is required within this area.

5.6 Summary

In summary, consequential of lower-order configural processing deficits, there is substantial evidence to suggest basic face detection and discrimination is impaired in schizophrenia. Such impairment has the potential to clearly impact on the later stages of face processing involving emotion perception and other social cognitive abilities. Deficient social cognition, specifically emotion processing, is related to neurocognitive impairment in areas such as memory, attention and executive functioning. This relationship between basic face processing, facial emotion processing and neurocognition will therefore be investigated in the following chapter.
Chapter 6  Integration of Findings

The previous three chapters have detailed the impairment of schizophrenia patients on measures of both non-social and social cognition. Specifically, schizophrenia patients showed deficits across three constructs; neurocognition, facial emotion processing and configural face processing. As discussed, there has been a reasonable degree of research investigating neurocognition and emotion processing in schizophrenia, in contrast, less research has been completed on the relationship with lower-level face processing. The current chapter will assess the relationships between neurocognitive ability, emotion processing and face processing. In particular, how neurocognition and face processing may impact upon emotion processing and whether higher-order functions, i.e. memory, attention, executive functioning, and/or more basic perceptual problems, i.e. configural processing, are related to the facial emotion processing problems commonly reported in schizophrenia. Furthermore, the current chapter investigates whether neurocognitive performance has a direct or indirect influence on emotion processing.

The following section will briefly review the tasks used to assess the three broad constructs of neurocognition, emotion processing and face processing in the current body of work. Thereafter, the relationship between performance on these assessment methods will be investigated via a series of correlations. Subsequently, two separate models detailing the relationship between neurocognition, emotion processing, and face processing for schizophrenia patients will be proposed and assessed.

6.1 Review of Neurocognition, Emotion Processing & Face Processing Assessment

Figure 20 summarises the three broad constructs of neurocognition, emotion processing and face processing as well as the constituent parts of each construct and the specific assessment methods used.
As described in Chapter 3, neurocognition was considered in relation to several main domains. The RBANS assessed immediate memory (IM) and delayed memory (DM), attention (ATT), language (LANG) and visuospatial/constructional ability (VSC) also producing a total assessment score (RBTOT). The Zoo Map assessed planning (ZOO), the Hayling Sentence Completion test assessed inhibition (HSCT), and the Brixton assessed switching/flexibility (BRIX), each of which are aspects of executive functioning. As discussed in Chapter 4, emotion processing was assessed via total scores for both discrimination (TDISC) and labelling (TLAB) task paradigms, which provided accuracy scores for five universal emotions, i.e. happy (HAP), sad (SAD), angry (ANG), fearful (FEAR) and neutral (NEUT). Lastly, as discussed in Chapter 5, face processing was assessed for featural processing via the Featural task (FEAT), first-order configural processing via the Scrambled faces task (SCRAM; difference between scrambled and non-scrambled conditions), second-order configural processing via the Spacing task (SPAC) and Fractured faces task (FFT; proportion of correctly identified fractured faces out of those correctly identified when whole), and finally holistic processing via the Complete-over part probe advantage (CPA) task and the Mooney faces task (MOON).
6.2 Statistical Analysis

6.2.1 Relative Task Performance

As the various assessment methods differed in scoring range, raw scores were transformed into standardised z-scores prior to conducting independent samples t-tests. Thus, performance on each of the task measures is illustrated by standardised z-scores relating to the number of standard deviations away from control performance; results are displayed Figure 21.

![Figure 21. Standardised Performance of Schizophrenia Patients on all Task Measures](image)

As shown, schizophrenia patients demonstrated impaired performance across aspects of all three broad constructs with clear impairment on memory, total emotion recognition and discrimination and the assessment of second-order configural and holistic face processing (SPAC & CPA).

6.2.2 Between Task Correlations

To explore the relationship between neurocognition, emotion processing and face processing in the current sample of participants, correlations coefficients were computed between the task variables detailed in Figure 20 and Figure 21. Any missing values or outliers more than three standard deviations away from the mean were removed before analysis.
standard deviations from the group mean were replaced with the group mean. Correlations were performed for the two groups separately; the correlation coefficients are shown in Table 18 for the control participants and Table 19 for the schizophrenia patients. It must be noted, there were a large number of correlations computed, thus potentially increasing the likelihood of Type 1 error. When the analysis was Bonferroni corrected for the 22 assessment methods, i.e. \( p < 0.05/22 = 0.002 \), several significant correlations remained. Considering the correction assumes independence of measures (which they were not), it is most likely excessively stringent, thus, although the correction is reported in the tables, the following written section reports on the significant correlations prior to Bonferroni correction.
Table 18. Correlations Between Task Measures for Control Participants

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<th>LANG</th>
<th>ATT</th>
<th>DM</th>
<th>RBTOT</th>
<th>HSCT</th>
<th>BRIX</th>
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Note: Pearson’s Correlations Coefficients. IM; RBANS Immediate memory, VSC; RBANS Visuospatial/constructional, LANG; RBANS Language, ATT; RBANS Attention, DM; RBANS Delayed memory; RBTOT; RBANS Total score, HSCT; Hayling Sentence Completion test, BRIX; Brixton test, ZOO; Zoo Map test, HAP; emotion recognition happy, SAD; emotion recognition sad, NEUT; emotion recognition neutral, ANG; emotion recognition angry, FEAR; emotion recognition fear, TLAB; emotion labelling total score, TDISC; emotion discrimination total score, FFT; Fractured Faces task (proportion of correctly identified fractured faces out of those correctly identified when whole); SCRAM; Scrambled Faces task (difference between scrambled and non-scrambled conditions), FEAT; Featural task total score, SPAC; Spacing task total score, CPA; Complete-over part probe advantage total score, MOON; Mooney Faces task total score.

* p<0.05, ** p<0.01, † p<0.002 (Bonferroni corrected)
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<th>FEAR</th>
<th>TLAB</th>
<th>TDISC</th>
<th>FFT</th>
<th>SCRAM</th>
<th>FEAT</th>
<th>SPAC</th>
<th>CPA</th>
<th>MOON</th>
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</thead>
<tbody>
<tr>
<td>IM</td>
<td>0.551†</td>
<td>0.527**</td>
<td>0.565†</td>
<td>0.722†</td>
<td>0.870†</td>
<td>0.235</td>
<td>0.058</td>
<td>0.297</td>
<td>0.231</td>
<td>0.327</td>
<td>0.213</td>
<td>0.075</td>
<td>0.426*</td>
<td>0.361</td>
<td>0.340</td>
<td>0.079</td>
<td>-0.116</td>
<td>0.084</td>
<td>0.108</td>
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<td>0.429*</td>
<td>0.474**</td>
<td>0.749†</td>
<td>0.370*</td>
<td>0.220</td>
<td>0.361</td>
<td>0.124</td>
<td>0.196</td>
<td>0.250</td>
<td>0.061</td>
<td>0.353</td>
<td>0.291</td>
<td>0.324</td>
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<td>0.068</td>
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<td>-0.017</td>
<td>0.047</td>
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<td>-0.156</td>
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<td>0.428*</td>
<td>0.348</td>
<td>0.124</td>
<td>0.136</td>
<td>0.179</td>
<td>0.213</td>
<td>0.283</td>
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<td>0.378*</td>
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<td>0.097</td>
<td>0.233</td>
<td>0.030</td>
<td>0.008</td>
<td>0.147</td>
<td>0.310</td>
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<td>BRIX</td>
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<td>0.298</td>
<td>0.328</td>
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<td>-0.193</td>
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<td>ZOO</td>
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<td>0.157</td>
<td>0.403*</td>
<td>0.314</td>
<td>0.304</td>
<td>0.470*</td>
<td>0.289</td>
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<td>-0.286</td>
<td>0.350</td>
<td>0.303</td>
<td>0.598**</td>
<td>0.288</td>
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<td>HAP</td>
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<td>0.081</td>
<td>0.502**</td>
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<td>0.574**</td>
<td>0.198</td>
<td>0.265</td>
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<td>0.314</td>
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<td>SAD</td>
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<td>0.287</td>
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<td>0.712†</td>
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<td>0.152</td>
<td>-0.505**</td>
<td>0.058</td>
<td>0.246</td>
<td>0.434*</td>
<td>0.453*</td>
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<tr>
<td>NEUT</td>
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<td>0.441*</td>
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<td>0.159</td>
<td>-0.371</td>
<td>0.466*</td>
<td>0.342</td>
<td>0.311</td>
<td>0.429**</td>
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<td>0.740†</td>
<td>0.521**</td>
<td>0.504**</td>
<td>-0.290</td>
<td>0.621†</td>
<td>0.408*</td>
<td>0.459*</td>
<td>0.088</td>
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<tr>
<td>FEAR</td>
<td>0.840†</td>
<td>0.294</td>
<td>0.325</td>
<td>-0.495**</td>
<td>0.249</td>
<td>0.259</td>
<td>0.478*</td>
<td>0.399*</td>
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<tr>
<td>TLAB</td>
<td>0.494**</td>
<td>0.437</td>
<td>0.454**</td>
<td>0.509**</td>
<td>0.420*</td>
<td>0.602†</td>
<td>0.444*</td>
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<td>0.097</td>
<td>-0.284</td>
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<tr>
<td>FFT</td>
<td>-0.267</td>
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<td>-0.072</td>
<td>0.153</td>
<td>0.051</td>
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<tr>
<td>SCRAM</td>
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<td>-0.083</td>
<td>-0.373</td>
<td>-0.211</td>
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<tr>
<td>FEAT</td>
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<td>0.480**</td>
<td>0.025</td>
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<tr>
<td>SPAC</td>
<td>0.548**</td>
<td>0.382*</td>
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<td>CPA</td>
<td>0.328</td>
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</tbody>
</table>

Note: Pearson’s Correlations Coefficients. IM; RBANS Immediate memory, VSC; RBANS Visuospatial/constructional, LANG; RBANS Language, ATT; RBANS Attention, DM; RBANS Delayed memory; RBTOT; RBANS Total score, HSCT; Hayling Sentence Completion test, BRIX; Brixton test, ZOO; Zoo Map test, HAP; emotion recognition happy, SAD; emotion recognition sad, NEUT; emotion recognition neutral, ANG; emotion recognition angry, FEAR; emotion recognition fear, TLAB; emotion labelling total score, TDISC; emotion discrimination total score, FFT; Fractured Faces task (proportion of correctly identified fractured faces out of those correctly identified when whole); SCRAM; Scrambled Faces task (difference between scrambled and non-scrambled conditions), FEAT; Featural task total score, SPAC; Spacing task total score, CPA; Complete-over part probe advantage total score, MOON; Mooney Faces task total score.

* p<0.05, ** p<0.01, † p<0.002 (Bonferroni corrected)
**Control Participants**

As indicated in Table 18, within the neurocognition construct there were medium to large correlations between RBANS variables, however, no significant correlations for the executive functioning task variables i.e. HSCT, Brixton Task and Zoo Map. For the emotion processing construct there were significant correlations between some but not all of the emotional expressions. The expression of fear appeared to show the most correlations with other emotion processing variables as did the total accuracy scores for both emotion labelling and discrimination. The large correlation between emotion discrimination and emotion labelling supports the notion the two tasks were assessing the same underlying construct. For the face processing construct there were significant correlations between the Featural task and the Spacing task as well as between the Mooney faces task and the Spacing task.

Between the neurocognition and emotion processing task variables, several significant correlations were observed. Happy and fearful emotions were correlated with the HSCT and the Zoo Map. The HSCT was also correlated with the sad emotion and total accuracy for the emotion labelling task. Neutral expression was correlated with the attention subsection of the RBANS as well as the total RBANS score. The language subsection of the RBANS was correlated with angry expression as well as the total accuracy score for emotion discrimination. For the face processing and emotion processing task variables, the FFT showed a medium correlation to the anger emotion. The Spacing task also showed correlations with the total accuracy score for the emotion labelling task and specifically the fear emotion. The CPA task was the only face processing variable to show correlations with the neurocognition variables, specifically with the immediate memory and language subsections of the RBANS and the total RBANS score.

**Schizophrenia Patients**

As indicated in Table 19, within the neurocognition construct there were medium to large correlations between all of the RBANS variables. Further, the HSCT was significantly correlated with the visuospatial/constructional subsection of the RBANS as well as RBANS total score and the Zoo Map. The Zoo Map was also correlated with the delayed memory subsection of the RBANS, the total RBANS score and the Brixton. For the emotion processing construct, similarly to controls, there were significant correlations between some but not all of the
emotional expressions. Again, the expression of fear appeared to show the most correlations with other emotion processing variables as did the total accuracy score for emotion labelling. There was also a correlation between angry and happy emotions and a correlation between total accuracy on emotion discrimination and neutral as well as angry emotions. Again, the large correlation between total accuracy score for emotion discrimination and emotion labelling supports the notion that the two tasks were assessing the same underlying construct. For the face processing construct there were significant correlations between the CPA task and the Featural task as well as the Spacing task. Further, the Spacing task was also correlated with the Featural task and the Mooney faces task.

Between the neurocognition and emotion processing task variables, several significant correlations were observed. The attention subsection of the RBANS was correlated with happy, sad, angry emotions and the total accuracy score for emotion labelling. The immediate memory subsection of the RBANS was correlated with fearful emotion. The total accuracy score for emotion discrimination was correlated with delayed memory and the RBANS total. The Zoo Map was correlated with neutral and happy emotion as well as the total accuracy score for emotion labelling.

For the face processing and emotion processing task variables, the angry emotion was significantly correlated with all face processing variables except the Scrambled faces task and the Mooney faces task. The total accuracy score for the emotion labelling task was significantly correlated with all face processing variables. The Scrambled faces task was correlated with sad emotion, the CPA task was correlated with happy, sad and fear emotions, and the Mooney faces task was correlated with neutral, sad and fear emotions. The Featural task was correlated with neutral emotion and the total accuracy score for the emotion discrimination task. The Spacing task was also correlated with the total accuracy score for the emotion discrimination task. For the face processing and neurocognition task variables, the CPA task was correlated with the Brixton and Zoo Map and the Mooney faces task was correlated with the language subsection of the RBANS.

These results indicate that both neurocognition and face processing are related to aspects of emotion processing for healthy controls and schizophrenia patients. Therefore, deficits in emotion processing may be worsened by impaired neurocognitive ability and/or lower-order perceptual problems. Interestingly, there were more significant correlations between the
emotion processing tasks and the face processing tasks for schizophrenia patients than healthy
controls, and accordingly, the strength of these correlations were on average stronger.

6.2.3 Between-Construct Relationship

To assess the overall relationship between the three broad constructs for schizophrenia patients,
a composite score was established for each construct. These composite construct scores were
derived by summing the standardised z-scores for each relevant task, thus, representing an
average deviation from control performance for each construct. The averaged construct scores
are observable in Figure 22.

![Figure 22. Standardised Performance of Schizophrenia Patients on Three Broad Constructs](image)

Independent samples t-tests confirmed impaired performance of schizophrenia patients
compared to controls on the overall assessment of each construct. Greatest impairment was
observable for emotion processing ($t(56)=6.49$, $p<0.001$), followed by neurocognition
($t(56)=7.03$, $p<0.001$), and then face processing ($t(56)=6.30$, $p<0.001$). As indicated in Table 20,
for schizophrenia patients, there were significant correlations between neurocognition and
emotion processing as well as between face processing and emotion processing.
Table 20. Between-Construct Correlations

<table>
<thead>
<tr>
<th>Construct</th>
<th>Emotion Processing</th>
<th>Face Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurocognition</td>
<td>0.391, <em>p</em> &lt; 0.05</td>
<td>0.284, <em>p</em> = 0.067</td>
</tr>
<tr>
<td>Emotion Processing</td>
<td>0.672, <em>p</em> &lt; 0.01</td>
<td></td>
</tr>
</tbody>
</table>

Note: Pearson’s correlation coefficients

The correlations between the three constructs indicates emotion processing may be impacted upon by impaired neurocognitive ability and/or lower-order perceptual problems pertinent to the processing of facial information i.e. configural information. This is line with numerous studies that have demonstrated a relationship between cognition and emotion.

Zajonc (1984) and Lazarus (1984) provide an interesting, yet heated conflict of opinion regarding the relationship between cognition and emotion. Zajonc argues that the two constructs are separate and partially independent, and he suggests that emotion can precede cognition. In contrast, Lazarus argues that emotion is dependent upon cognition, thus cognition is a necessary antecedent to emotion. It must be noted that a contribution to this argument is beyond the scope of the current work as the emotion processing tasks utilised were restricted to facial information, and do not assess faculties other than the visual system, nor does the current work investigate emotional experience. Nonetheless it is worth noting the primacy and independence issues surrounding cognition and emotion which parallel this body of work, in that some would argue an emotional impairment is secondary to cognitive impairment (Lazarus, 1984), whereas others would argue emotion is primary and independent of cognition (Zajonc, 1984).

In healthy populations it has been established that memory is superior for emotional content compared to non-emotional content; this is apparent for LTM (Kensinger, 2007) and STM (Langeslag et al., 2009). Other studies using backward-masking paradigms have demonstrated that emotional content can be processed automatically without conscious awareness (Pegna et al., 2008). For schizophrenia patients, neurocognition and social cognition (including emotion processing) has been represented as two separate domains (van Hooren et al., 2008). However, it has been demonstrated that emotion recognition is associated with attention, verbal and spatial memory and language ability (Kohler et al., 2000) and executive functioning (Sachs et al., 2004; Whittaker et al., 2001). Similarly others have found that emotion discrimination and facial memory performance is related to cognitive flexibility, verbal memory and language ability (Sachs et al., 2004). Thus, it does appear that basic cognitive functions do impact upon facial emotion.
processing, however, does neurocognitive ability directly influence emotion processing or could this be an indirect influence?

Some authors have argued that the emotion processing deficit shown by schizophrenia patients can be explained by generalised cognitive decline rather than a specific deficit processing facial emotional information (Sachs et al., 2004; Salem et al., 1996). Similarly, others have nominated correlations between emotion processing and medication, duration of illness and IQ measures (Whittaker et al., 2001) as well as severity of negative symptoms (Sachs et al., 2004) all as explanations of the emotion processing problems in schizophrenia.

In contrast, others argue for an emotion specific deficit (Bryson et al., 1997). While neurocognitive ability can account for some of the variance in emotion processing, the deficit shown by schizophrenia patients is to a degree, specific to the emotional content of the face. There have also been suggestions that the facial emotion processing deficits shown by schizophrenia patients are reflected by a generalised problem perceiving faces (Mueser et al., 1997). The current body of work argues that both neurocognitive abilities such as attention, memory and executive functioning as well as perceptual problems relating to facial information, are both contributors to impaired facial emotion processing in schizophrenia.

### 6.2.4 Model Testing

Considering the relationship between each of the three constructs, it was proposed that both neurocognitive ability and face processing ability impact upon a persons’ ability to recognise emotional expression within a face. Thus, a model was proposed to further explore the relationship between variables, see Figure 23. This model suggests that both neurocognition and face processing have a direct influence on emotion processing.

![Figure 23. Model 1: Neurocognition and Face Processing Impact Upon Emotion Processing](image-url)
It is reasonable to consider that the influential neurocognitive factors that impact upon emotion processing may also impact upon face processing. Therefore, a second model was proposed to explore the notion that neurocognition would affect emotion processing indirectly, through its impact on face processing, see Figure 24.

![Figure 24. Model 2: Indirect Influence of Neurocognition on Emotion Processing](image)

Models 1 and 2 were assessed using the performance data of the schizophrenia patients. A simple multiple regression was used to statistically explore Model 1, and assess how much of the variance in emotion processing could be explained by neurocognition and face processing. Furthermore, a hierarchical multiple regression analysis was conducted to examine Model 2, and assess the indirect relationship between neurocognition and emotion processing. Neurocognition was entered at stage one, followed by face processing at stage two. It must be noted that the correlations reported in this chapter do not necessarily reflect causal links. This notwithstanding, such regression model testing is appropriate considering the analysis was theory-driven and significant correlations were established. Ideally, structural equation modelling, specifically path analysis, would be suitable for this type of investigation, however, such techniques were not suitable for the current body of work considering the limited sample size.

**Assumption Testing for Multiple Regression**

Sample size: According to Stevens (1996), “for social science research about 15 subjects per predictor are needed for a reliable equation” pp72. As there were two independent predictors, the sample size of 29 was sufficient.

Multicollinearity and Singularity: As indicated in Table 20, significant correlations were demonstrated between the independent variables i.e. neurocognition and face processing, and
the dependent variable i.e. emotion processing. Schizophrenia patients who demonstrated better neurocognitive ability tended to demonstrate better emotion processing ($r=.391, p<0.05$). Likewise patients who demonstrated better face processing also tended to demonstrate better emotion processing ($r=.672, p<0.01$). There were medium correlations between the independent variables ($r=.284, p=0.067$). Furthermore the tolerance statistics were high for both neurocognition (0.919) and face processing (0.919). These variables were represented by separate measurements; thus the assumptions of multicollinearity and singularity were upheld.

Outliers, Normality, Linearity, Homoscedasticity, and Independence of Residuals: Normal Probability Plots indicated no major deviations from normality and scatterplots indicated no clear systematic pattern to the standardised residuals for either of the independent variables or any presence of outliers. Furthermore, inspection of the Mahalanobis distances indicated no value exceeded the critical value of 13.82 verifying a lack of outliers (Tabachnick & Fidell, 1996).

**Results**

Model 1: The simple regression analysis when both independent variables were entered at the same stage revealed that neurocognition and face processing together explained 49.5% of the variability in emotion processing ($R=0.704$, adj $R^2=0.457$; $F(2,26)=12.77, p<0.001$). Interestingly however, only face processing made a significant unique contribution to the model (beta=0.611, $p<0.001$), the contribution made by neurocognition was not significant (beta=0.217, $p>0.05$). Given the neurocognitive factors that may impact upon emotion processing would also impact upon face processing, the second model proposing an indirect influence was assessed.

Model 2: The regression statistics are given below in Table 21. Consistent with the simple regression, the results indicated that performance on neurocognition and face processing significantly predicted performance on emotion processing, together explaining 49.5% of the variance ($R=0.704$, adj $R^2=0.457$; $F(2,26)=12.77, p<0.001$). Neurocognitive ability alone explains only 15.3% of the variation in emotion processing. Introducing face processing explained an additional 34.3% of the variation in emotion processing. When both independent variables were included in the model, neurocognition was no longer significant. This was consistent with the proposal that neurocognitive ability affects emotion processing indirectly through its impact on face processing. Patients who had better neurocognitive ability demonstrated better face processing and hence showed better emotion processing. Not surprisingly, the most important
predictor of emotion processing was face processing. As expected, patients who were better able to process facial information were better able to perceive the emotional content of a face.

Table 21. Results of Hierarchical Regression Assessing Model 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Stage 1 Squared Semi-partial Correlation</th>
<th>Standardised Regression Coefficient</th>
<th>Stage 2 Squared Semi-partial Correlation</th>
<th>Standardised Regression Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurocognition</td>
<td>0.153</td>
<td>0.391*</td>
<td>0.043</td>
<td>0.217</td>
</tr>
<tr>
<td>Face Processing</td>
<td></td>
<td>0.343</td>
<td></td>
<td>0.611**</td>
</tr>
</tbody>
</table>

R² = 0.153*  
R² Change = 0.343**  
R² = 0.495

Note: N=29. Dependent variable: emotion processing, Independent variables: neurocognition and face processing.  
* p<0.05, ** p<0.001

6.2.5 Symptom Correlates

Throughout Chapters 3-5, few consistent correlations between symptom variables and task performance for schizophrenia patients were observed. However, when the task variables were collapsed into one of the three broad constructs, there were some relationships between the clinical characteristics of the sample and social and non-social cognitive ability. For example, as shown in Table 22, neurocognitive ability was negatively correlated with general and total PANSS ratings. Schizophrenia patients, who exhibited higher PANSS ratings and thus were more unwell, demonstrated lower neurocognitive ability, patients who were less symptomatic demonstrated better neurocognitive ability. Similarly, emotion processing was negatively correlated with negative PANSS ratings, thus schizophrenia patients, who exhibited more negative symptoms were more impaired on emotion processing tasks.

Table 22. Symptom Correlations with Neurocognition, Face Processing, Emotion Processing

<table>
<thead>
<tr>
<th></th>
<th>Neurocognition</th>
<th>Face Processing</th>
<th>Emotion Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>PANSS Positive</td>
<td>-0.291</td>
<td>-0.054</td>
<td>-0.037</td>
</tr>
<tr>
<td>PANSS Negative</td>
<td>-0.300</td>
<td>-0.151</td>
<td>-0.371*</td>
</tr>
<tr>
<td>PANSS General</td>
<td>-0.405*</td>
<td>0.143</td>
<td>-0.058</td>
</tr>
<tr>
<td>PANSS Total</td>
<td>-0.410*</td>
<td>-0.007</td>
<td>-0.212</td>
</tr>
</tbody>
</table>

PANSS: Positive and Negative Symptom Scale  
*p<0.05
6.3 Summary

The results from the current chapter indicate that schizophrenia patients show neurocognitive impairment, particularly for assessment of memory, a generalised emotion processing impairment and problems processing facial configural information. Schizophrenia patients and healthy controls demonstrated correlations between performance on the different assessment methods of neurocognition, emotion processing and face processing. When performance was collapsed across these three broad constructs, schizophrenia patients showed a generalised performance deficit across each construct, with the greatest impairment for emotion processing. Furthermore, there were significant correlations between performances on each construct. Multiple regression analyses indicated that although neurocognition and face processing both explained a significant proportion of the variance in emotion processing, the effect of neurocognition was indirect and mediated by face processing. It was also revealed that performance on the neurocognitive tasks was associated with general symptom severity and performance on the emotion processing tasks was associated with negative symptom severity. This later result is consistent with section 4.3.3 which indicated a relationship between emotion processing deficits and negative symptoms (Mandal et al., 1999; Martin et al., 2005); specifically alogia (Gaebel & Wolwer, 1992) and flat affect (Gur et al., 2006). Furthermore, social isolation is a characteristic negative symptom; patients who tend to experience more negative symptoms consequently spend less time socialising (Andreasen, 1982).

As briefly proposed in Chapter 4, there is evidence to suggest that some emotional expressions are more conducive to certain face processing styles than others. For example, previous investigations have shown that face inversion differentially alters responses to emotional compared to neutral faces (Chambon et al., 2006). Specifically, healthy controls responded more conservatively when emotional faces were inverted and more liberally when neutral faces were inverted. This suggests that the configural disruption resultant of face inversion may vary upon the emotional content, thus emotion processing and configural face processing interrelate. Unlike healthy controls, schizophrenia patients show the same pattern of response to emotions regardless of orientation. Thus, the typical change in response that is associated with configural disruption of facial emotional information was not apparent in schizophrenia patients.

This notion that some emotional expressions may rely more on configural information than other emotional expressions, was supported by correlations between the emotion labelling task
variables and the configural face processing task variables. For schizophrenia patients (and to a degree controls), performance on the configural face processing tasks, particularly the FFA, CPA and Spacing tasks, was related to recognition of different emotional expressions, particularly anger. Impairment in configural face processing was consistently related to a reduced ability to recognise emotional expressions of anger, and less consistently with fear and sadness.

An explanation of why some emotions rely on configural processing more than others may lie with the actual qualities and characteristics of the different expressions. For example, expressions of happiness are generally recognised quite accurately, whereas other, more negative emotions such as fear, sadness and anger are less accurately recognised. It is argued that the relative overlap in features, or action units, for these negative emotions renders them more difficult. Recognition of these emotional expressions may therefore not benefit from featural processing strategies, and rely more on configural or holistic processing strategies, whereby the action units are processed relative to one another.

To explore these claims further, future investigations should assess differential face inversion effects (FIE) for different emotional expressions. If these claims are valid, happy facial expressions should elucidate less of a FIE due to a reliance on featural processing for this emotion and more of a FIE for the negative emotions. If happy facial expressions are processed more featurally, this would explain why schizophrenia patients are somewhat less impaired compared to the negative emotions which are proposed to be processed more configurally. In this sense, it is suggested schizophrenia patients have a generalised impairment in processing facial emotional content; however, some emotional expressions may be harder than others due to an extra reliance on configural information.

While the model tested in the current chapter explained a significant 49.5% of the variance in emotion processing, there are clearly other important factors contributing to the impairment. Such factors contributing to the other 50.5% of the variance in emotion processing, may include neurobiological factors such as amygdala dysfunction. The role of the amygdala in emotion processing is well established (Costafreda et al., 2008), along with other limbic structures i.e. hippocampus, anterior cingulate, as well as tight connections to the prefrontal cortex (Phillips et al., 2003a). Structurally, schizophrenia patients show reduced size and volume of limbic structures. Furthermore, functionally, schizophrenia patients also demonstrate reduced activation in such areas to emotional cues. Structural and functional abnormalities in cortical
regions relating to emotion perception are considered contributors to the impairment in facial emotional information observable in schizophrenia (Phillips et al., 2003b).

Other important issues worthy of note that may be contributing to the extra 50.5% of variance in emotion processing for the schizophrenia patients in the current sample (but not specifically examined here) may include motivation, medication, personality factors, and trauma (PTSD). As well as other individual differences in IQ, education, gender, socioeconomic status, and family cohesiveness.
Chapter 7 Bipolar Disorder

The previous chapters have investigated impairment in non-social and social cognition in schizophrenia. The results from this work invoked questions relating to the diagnostic specificity of impairments shown by the schizophrenia patients. That is, are the performance deficits secondary to the illness and a result of psychopathological characteristics common to other mental illness, or are the deficits specific to the underlying aetiology of schizophrenia? As indicated by Addington et al. “findings suggest that while individuals with schizophrenia are impaired in facial affect recognition relative to non-clinical controls, performance deficits compared to clinical controls are less consistently shown” (Addington et al., 2006) p143. To ascertain whether deficits are specific to schizophrenia or problematic for other psychosis patients, the current chapter will investigate non-social and social cognition in a group of bipolar disorder patients compared to schizophrenia patients.

This chapter will begin with a summary of the clinical similarities and differences between bipolar disorder and schizophrenia. Then the literature investigating neurocognition and social cognition in bipolar disorder will be discussed. Thereafter the current aims and hypotheses will be outlined followed by a description of the bipolar disorder recruited for this thesis. The procedures and results will then be discussed followed by summary and concluding remarks regarding the specificity of the cognitive impairments shown by the schizophrenia patients.

7.1 Bipolar Disorder vs. Schizophrenia

Bipolar disorder is a psychiatric disorder characterised by periods of extreme elevated mood, i.e. mania, alternating with normal mood and periods of extreme reduced mood, i.e. depression. During these extreme mood episodes, psychotic features such as delusions and hallucinations may be present. The following sections will consider the clinical similarities and differences between bipolar disorder and schizophrenia.

7.1.1 Similarities

Bipolar disorder and schizophrenia are considered two categorically different disorders as classified by the DSM-IV (APA, 2000) and the ICD-10 (WHO, 1993). However, the two
disorders share some distinct similarities which have led researchers to draw comparisons (Adler & Strakowski, 2003; Berrettini, 2000; Demily et al., 2009; Moller, 2003; Murray et al., 2004). The prevalence rate for bipolar disorder and schizophrenia is similar, each affecting around 1% of the population. Both disorders typically first present in early adulthood; early 20’s for bipolar disorder males and females, and mid-20’s for schizophrenia males and late-20’s for schizophrenia females (APA, 2000). Both disorders may be associated with poor premorbid social functioning (Cannon et al., 1997) as well as more frequent and severe life events compared to controls, particularly for females (Bebbington et al., 1993). There are strong genetic links for bipolar disorder and schizophrenia (Cardno et al., 2002), with the risk for developing either disorder increasing as the genetic relationship between family members is stronger.

Despite the differentiation of diagnostic criteria, bipolar disorder and schizophrenia can show very similar clinical presentation. Many schizophrenia patients exhibit symptoms of depression and/or mania similar to bipolar disorder, and both bipolar disorder and schizophrenia patients can experience severe psychotic symptoms such as delusions and hallucinations. Particularly during psychotic episodes, the presentation of the two disorders can be very similar, thus making differentiation difficult (Doran et al., 1986). Furthermore, the psychopharmacological mechanisms of both bipolar disorder and schizophrenia implicate the dopaminergic system which is often a target for treatment of these psychotic symptoms in both disorders. The severe psychotic and affective symptoms experienced by schizophrenia and bipolar disorder patients’ can result in the prescription of antipsychotic medication for extended periods of time. Additionally, patients may experience long periods of time in psychiatric institutions or community care units without ongoing integration into typical community living.

#### Differences

While there are similarities between bipolar disorder and schizophrenia there are clear distinctions to be made. For example, in contrast to bipolar disorder the psychotic symptoms presented in schizophrenia occur in the absence of major mood disturbance. Furthermore, there is a second peak in the age at onset for schizophrenia for females that is not apparent for bipolar disorder. This typically occurs post-menopausally suggesting a role of oestrogen in the development of the disorder (Castle et al., 1995; Hafner et al., 1993). There is also evidence to suggest specific structural brain abnormalities that may differentiate schizophrenia and bipolar disorder. For example, bipolar disorder has been associated with enlargement of the amygdala,
whereas schizophrenia has been associated with a reduction of the hippocampus (Altshuler et al., 1998). This is consistent with other reports of larger amygdala in bipolar disorder and smaller amygdala in schizophrenia (Strakowski et al., 1999). Additionally, the functional outcome for bipolar disorder patients tends to be better than for schizophrenia patients (Marneros et al., 1990). Bipolar disorder patients are also more commonly prescribed mood stabiliser medication.

The premorbid IQ of schizophrenia patients has been shown to be significantly lower than that of bipolar disorder patients (Gilvarry et al., 2000). While schizophrenia and bipolar disorder typically both exhibit some level of cognitive dysfunction, the severity of this impairment contrasted between the two disorders is debatable (Barch, 2009). The following sections will comment on the cognitive deficits demonstrated by bipolar disorder and how this classically compares to the impairment demonstrated in schizophrenia.

### 7.2 Neurocognition in Bipolar Disorder

Bipolar disorder patients show a range of neurocognitive deficits (Bearden et al., 2001; Coffman et al., 1990), particularly sustained attention and verbal memory (Quraishi & Frangou, 2002) as well as verbal learning, psychomotor speed and executive function including response inhibition, abstraction and set shifting (Robinson et al., 2006). These deficits are not related to education or IQ and are observable cross-culturally. Similar to schizophrenia patients, bipolar disorder patients who exhibit greater neurocognitive deficits in memory tend to have poorer social functioning (Atre-Vaidya et al., 1998).

Neurocognitive impairment is observable over different stages of the disorder (Bearden et al., 2001). For example, patients exhibiting mania demonstrate deficits in memory and planning ability (Murphy et al., 1999) as do those that are in the depressed phase and those that are not currently experiencing mood symptoms (for a review see Malhi et al., 2004). Additionally, impairment in frontal lobe functioning in bipolar disorder patients exhibiting depression was greater than that of unipolar patients exhibiting depression (Borkowska & Rybakowski, 2001); the bipolar disorder patients showed greater impairment on the WCST, non-verbal aspects of the WAIS, the Stroop test, the verbal fluency test and the Trail Making Test. Furthermore, there is some evidence to suggest that some aspects of neurocognition are preserved in euthymic bipolar disorder patients (Quraishi & Frangou, 2002; van Gorp et al., 1999), i.e. when patients are exhibiting a normal non-depressed, non-manic mood. Others have shown generalised cognitive
impairment for euthymic patients (Tham et al., 1997), as well as a specific impairment in declarative memory (van Gorp et al., 1999).

In this brief summary, there is evidence to show that bipolar disorder patients do show neurocognitive impairment, but how do these deficits compare to those of schizophrenia patients? This issue of diagnostic specificity has been explored to a degree.

7.2.1 Neurocognitive Profiles of Bipolar Disorder vs. Schizophrenia

While it is commonly thought that bipolar disorder patients show less impairment in neurocognition than schizophrenia patients, the empirical evidence is somewhat conflicting. Some studies investigating cognitive functioning in both populations have indicated bipolar disorder patients demonstrate relatively less severe impairments or intact neurocognitive performance compared to schizophrenia patients. For example, in an early study using the WAIS, bipolar disorder patients showed significantly higher verbal IQ and performance IQ than schizophrenia patients (Abrams et al., 1981). Similarly, patients with schizophrenia have demonstrated worse performance on the RBANS relative to bipolar disorder patients (Dickerson et al., 2004; Hobart et al., 1999) as well as reaction time measures of sustained attention (Fleck et al., 2001). Landro et al. (1993) demonstrated schizophrenia patients show impairments in short-term and long-term memory compared to bipolar disorder patients and healthy controls; whereas bipolar disorder patients and healthy controls did not differ in performance. Schizophrenia patients have shown generalised neurocognitive impairment compared to bipolar disorder patients (and unipolar depression patients) despite showing equivalent premorbid IQ (Goldberg et al., 1993a). However, when patients exhibiting an overall current WAIS IQ below 90 were excluded from the analysis, only significant differences in problem solving and visual memory remained between the groups. Executive function has been shown to differentiate the groups: bipolar patients having superior performance on the WCST in some (Tam et al., 1998; Zihl et al., 1998) but not all studies (Morice, 1990); and category but not phonological verbal fluency being intact in bipolar disorder (Rossell, 2006).

Some studies have reported cognitive deficits in bipolar disorder just as severe as those seen in schizophrenia (Johnstone et al., 1985). Equivalent performance on measures of perceptual organization (Chey & Holzman, 1997), phonological verbal fluency (Rossell, 2006), memory, verbal ability, spatial ability and psychomotor speed has been reported in schizophrenia and
bipolar disorder (Hoff et al., 1990). Likewise, minimal differences were observed between the two patient groups on assessments of attention, long-term verbal memory, nonverbal intelligence and reasoning. Others have illustrated varied severity of impairment between the two patient groups on some, but not all measures (Krabbendam et al., 2000). For example, Dickerson et al. (2001) revealed bipolar disorder patients showed similar neurocognitive impairment on a wide range of measures except immediate memory.

While siblings of schizophrenia patients show impairment in visual information processing, spatial working memory and long delay verbal recall, siblings of bipolar disorder patients do not (Keri et al., 2001). Conversely, others have demonstrated relatives of both schizophrenia and bipolar disorder patients show deficits in memory, however, the relatives of schizophrenia patients were more impaired than the relatives of bipolar patients (McIntosh et al., 2005).

### 7.3 Social Functioning and Social Cognition in Bipolar Disorder

#### 7.3.1 Social Functioning

Patients with bipolar disorder show impaired social functioning (Dion et al., 1988; Sanchez-Moreno et al., 2009) similar to deficits reported in schizophrenia patients. For example, Dickerson et al. (2001) revealed that bipolar disorder patients did not differ from schizophrenia patients on ratings of competence of daily living, frequency of activity, participation in social activities, frequency of family contact or social relations. These patients were however, less impaired compared to schizophrenia patients on social acceptability, effectiveness and presentation, indicating some aspects of social functioning are worse than others for bipolar disorder patients. Similarly, Bellack et al. (1989) showed bipolar disorder patients demonstrate impaired social competence similar to non-negative syndrome schizophrenia patients. However, negative syndrome schizophrenia patients demonstrated lower verbal and non-verbal social skill compared to bipolar disorder, non-negative syndrome schizophrenia, schizoaffective disorder patients and healthy controls.

#### 7.3.2 Social Cognition

Bipolar disorder patients also demonstrate impairments on a range of social cognitive measures (Kim et al., 2009; Lahera et al., 2008; Phillips et al., 2003b). In addition, children at risk of
developing bipolar disorder also show deficits in social cognition, specifically emotion processing (Brotman et al., 2008). While some have indicated patients displaying mania demonstrate an overall impairment in emotion processing, and are particularly worse on the recognition of disgust and fear (Lembke & Ketter, 2002), others have reported better recognition for disgusted faces in bipolar mania (Harmer et al., 2002). In contrast, others have indicated no differences between controls and euthymic bipolar disorder patients in emotion processing (Venn et al., 2004).

There have been a number of studies to investigate differences in social cognition between bipolar disorder and schizophrenia. For example, Cutting and Murphy (1990) found that schizophrenia patients performed worse on a social knowledge test compared to patients displaying mania and those with major depressive disorder. Similarly, on measures of facial emotion discrimination, both bipolar disorder and schizophrenia patients showed significant impairment compared to healthy controls, however, this impairment was significantly greater for schizophrenia patients. Further, only schizophrenia patients showed impairment on a similar facial emotion recognition task and a neutral (non-emotional) facial recognition task (Addington & Addington, 1998). Loughland et al. (2002a) revealed that a restricted visual scanpath for facial information was relatively specific to schizophrenia, with bipolar disorder and major depression patients showing a scanpath pattern in between that of schizophrenia patients and healthy controls.

In contrast, others have indicated limited differences in social cognitive performance between patient groups. For example, Vaskinn et al. (2007) demonstrated that bipolar disorder and schizophrenia patients did not differ in visual emotion processing; however, did so in auditory emotion processing, with schizophrenia patients showing impaired performance. Others have demonstrated relatively similar performance of bipolar disorder and schizophrenia as well as schizoaffective disorder patients on emotion processing, however a schizophrenia impairment for non-emotional face perception (Bellack et al., 1996). Others have indicated no such group difference in facial recognition (Goldberg et al., 1993a).

In summary, while there are some inconsistencies regarding the particular differential impairment shown by bipolar disorder and schizophrenia patients, considering the psychopathological similarities, bipolar disorder provides a worthwhile comparison group to assess the diagnostic specificity of social and non-social cognitive dysfunction in schizophrenia. In view of the limited
investigation involving underlying processing styles in face perception (i.e. configural processing), particularly for bipolar disorder patients, the proposed research will also contribute to an understanding of bipolar disorder as well as schizophrenia.

### 7.4 Aims and Hypotheses

Several empirical aims were developed for the current chapter:

A. To assess neurocognition, emotion processing and face processing in bipolar disorder by comparing performance to healthy controls, and to assess the relative social and non-social cognitive strengths and weaknesses of bipolar disorder patients.

B. To compare performance of bipolar disorder patients to that of schizophrenia patients to assess the diagnostic specificity of the impairment observed in schizophrenia.

C. To compare bipolar disorder and schizophrenia group performance across the three broad constructs of neurocognition, emotion processing and face processing.

D. To explore the relationship between these constructs for each group using hierarchical multiple regression analysis.

E. To use discriminant functional analysis (DFA) to explore the ability of neurocognitive, emotion processing and face processing measures to accurately discriminate bipolar disorder from schizophrenia patients.

Based on the previous review of the literature, it was hypothesised that bipolar disorder patients would show impaired performance on the neurocognitive and emotion processing measures compared to healthy controls. It was questioned whether the facial emotion impairments were resultant of impaired perceptual processing styles underlying face perception i.e. configural face processing, thus no predictions were made regarding the face processing tasks. It was hypothesised that the predicted impairments shown by bipolar disorder patients would not be as severe as those demonstrated by schizophrenia patients.
7.5 Participants

Thirty individuals with Bipolar I disorder (aged 23 - 65 years) were recruited via community support groups and community care units. All were out-patients and had been euthymic at least three months prior and at the time of testing as established via the Bech-Rafaelsen Mania Scale (MRS, Bech, 2002) and initial mood screening questions (further mood assessment is detailed below). All participants were tested during a period of clinical stability as determined by the primary investigator. Diagnosis was confirmed using the SCID (First et al., 1996). Current symptomatology was assessed using the PANSS (Kay et al., 1987). None of the patients included in the sample experienced any co-morbid Axis 1 diagnoses at the time of testing. Six of the bipolar patients had received ECT in the past, however none within the year prior to testing. Eighteen patients had never used illicit drugs, nine had used illicit drugs experimentally, three had a history of recreational drug use, none had used illicit drugs within three months prior to testing. All participants met the following inclusion criteria: a) No history of neurological disorder or head trauma, b) No diagnosable current drug or alcohol abuse disorder, c) English spoken as first language, d) Aged between 18-65 years and e) Estimated IQ >85.

7.5.1 Demographic Characteristics

The demographic characteristics of the bipolar disorder patients compared to the schizophrenia patients and healthy control participants are summarised in Table 1. There was no significant difference in age between bipolar disorder patients, schizophrenia patients and controls. Females were significantly over represented among the bipolar disorder patients and males were significantly over represented among the schizophrenia patients compared to control participants. The handedness distribution did not differ significantly between the three groups. The bipolar disorder patients and schizophrenia patients did not differ in years of education, however both had completed fewer years compared to controls. The bipolar disorder patients did not differ in NART predicted IQ compared to controls and schizophrenia patients, however the schizophrenia patients showed significantly lower IQ than controls.
Table 23. Participant Demographic Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Controls $n=29$</th>
<th>Schizophrenia $n=29$</th>
<th>Bipolar disorder $n=30$</th>
<th>Comparisons$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>42.86 (11.33)</td>
<td>39.24 (11.12)</td>
<td>42.03 (11.88)</td>
<td>$F(2,85)=0.80$</td>
</tr>
<tr>
<td>% Male</td>
<td>45</td>
<td>72</td>
<td>30</td>
<td>$\chi^2(1,N=88)=10.90^*$</td>
</tr>
<tr>
<td>% Right-handed</td>
<td>83</td>
<td>90</td>
<td>93</td>
<td>$\chi^2(1,N=88)=1.68$</td>
</tr>
<tr>
<td>NART</td>
<td>113.93 (7.44)</td>
<td>106.28 (10.94)</td>
<td>109.50 (8.38)</td>
<td>$F(2,85)=5.25^*$</td>
</tr>
<tr>
<td>Education (years)</td>
<td>17.02 (2.55)</td>
<td>14.53 (2.83)</td>
<td>15.02 (3.30)</td>
<td>$F(2,85)=5.92^*$</td>
</tr>
</tbody>
</table>

Note: $^1$Comparisons refer to one-way analysis of variance (age, NART, education) and chi-squared tests (gender, handedness). NART: National Adult Reading Test.

* $p<0.01$

7.5.2 Education, Employment & Living Situation

Of the bipolar disorder patients, six had not completed secondary school, seven had completed secondary school and 17 had gone on to tertiary education. Three were employed full time, five part-time, three casual, two were unemployed, three completed home duties, two were students, two were retired and 10 were receiving disability pensions. One of the bipolar disorder patients was living in government housing, five were living in the family home and 24 were living independently.

7.5.3 Psychopathological Characteristics & Mood Assessment

As indicated in Table 2, there were no significant differences in age of illness onset or length of illness between the two patient groups. Schizophrenia patients showed significantly higher ratings on each of the PANSS measures as well as total PANSS score and the global assessment of functioning. There was no significant difference between bipolar disorder patients and schizophrenia patients on assessment of depression and anxiety from the BDI and BAI respectively. The bipolar disorder patients also completed the MRS to assess the severity of manic state. The scale consisted of 11 items rated on a five-point Likert scale from 0 (not present) to 4 (severe or extreme) resulting in a possible range of 0-44. On average patients bipolar disorder patients showed very low ratings of mania ($M=1.50$, $SD=1.74$), all were classified as having ‘no current mania’.
### Table 24. Psychopathological Characteristics of Schizophrenia Patients

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenia</th>
<th>Bipolar disorder</th>
<th>Comparisons1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at illness onset (years)</td>
<td>22.61 (6.66)</td>
<td>22.21 (9.39)</td>
<td>t(55)=0.19</td>
</tr>
<tr>
<td>Illness duration (years)</td>
<td>16.89 (10.46)</td>
<td>19.86 (12.06)</td>
<td>t(55)=-0.99</td>
</tr>
<tr>
<td>PANSS Positive</td>
<td>12.86 (4.58)</td>
<td>10.00 (3.10)</td>
<td>t(48.97)=2.80**</td>
</tr>
<tr>
<td>PANSS Negative</td>
<td>13.21 (6.10)</td>
<td>8.70 (1.95)</td>
<td>t(33.49)=3.79**</td>
</tr>
<tr>
<td>PANSS General</td>
<td>25.14 (6.63)</td>
<td>21.50 (3.61)</td>
<td>t(42.92)=2.61*</td>
</tr>
<tr>
<td>PANSS Total</td>
<td>50.86 (13.89)</td>
<td>40.20 (5.32)</td>
<td>t(35.81)=3.87**</td>
</tr>
<tr>
<td>GAF</td>
<td>53.14 (13.24)</td>
<td>68.93 (9.38)</td>
<td>t(57)=-5.30**</td>
</tr>
<tr>
<td>BDI</td>
<td>14.38 (11.33)</td>
<td>10.13 (9.79)</td>
<td>t(57)=1.54</td>
</tr>
<tr>
<td>BAI</td>
<td>15.48 (11.44)</td>
<td>11.93 (9.86)</td>
<td>t(57)=1.28</td>
</tr>
</tbody>
</table>

Note: 1Comparisons refer to independent samples t-tests. PANSS: Positive and Negative Syndrome Scale, GAF: Global Assessment of Functioning, BDI: Beck’s Depression Inventory, BAI: Beck’s Anxiety Inventory

* p<0.05, ** p<0.01

#### 7.5.4 Medication

Within the bipolar disorder patients, one was taking antipsychotic medication alone (atypical), five were taking mood stabilizers alone, one was taking an antidepressant alone, eight were taking antipsychotics (all atypical) and mood stabilisers, one was taking an antipsychotic (atypical) and an antidepressant, seven were taking antidepressants and mood stabilisers, four were taking a combination of antipsychotics (all atypical), antidepressants and mood stabilisers, and three were medication free. For those bipolar disorder patients taking antipsychotic medication (N=14), the average chlorpromazine equivalent (CPZe) was 245.35mg CPZe/day (SD=189.74), significantly lower than the average dose for the schizophrenia patients; 500.13 mg (t(37)=2.95, p<0.01).

#### 7.6 Procedure

Bipolar disorder patients followed the same procedure as the schizophrenia patients and healthy control participants described in Chapter 2. Bipolar disorder patients completed all the neurocognitive tasks detailed in Chapter 3, the emotion processing tasks detailed in Chapter 4, and the face processing tasks detailed in Chapter 5.

#### 7.7 Results

Consistent with the previous chapter, performance of the bipolar disorder patients was assessed on each of the neurocognitive, emotion processing and face processing measures described in Table 25.
## Table 25. Review of the Neurocognitive, Emotion Processing & Face Processing Measures

<table>
<thead>
<tr>
<th>Task Variable</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurocognition</td>
<td></td>
</tr>
<tr>
<td>RBANS Immediate Memory</td>
<td>IM</td>
</tr>
<tr>
<td>RBANS Delayed Memory</td>
<td>DM</td>
</tr>
<tr>
<td>RBANS Attention</td>
<td>ATT</td>
</tr>
<tr>
<td>RBANS Language</td>
<td>LANG</td>
</tr>
<tr>
<td>RBANS Visuospatial/constructional</td>
<td>VSC</td>
</tr>
<tr>
<td>RBANS Total Score</td>
<td>TBTOT</td>
</tr>
<tr>
<td>Zoo Map (Planning)</td>
<td>ZOO</td>
</tr>
<tr>
<td>Hayling Sentence Completion Test (Inhibition)</td>
<td>HSCT</td>
</tr>
<tr>
<td>Brixton Test (Switching/flexibility)</td>
<td>BRIX</td>
</tr>
<tr>
<td>Emotion Processing</td>
<td></td>
</tr>
<tr>
<td>Happy (Facial Emotion Recognition)</td>
<td>HAP</td>
</tr>
<tr>
<td>Sad (Facial Emotion Recognition)</td>
<td>SAD</td>
</tr>
<tr>
<td>Angry (Facial Emotion Recognition)</td>
<td>ANG</td>
</tr>
<tr>
<td>Fearful (Facial Emotion Recognition)</td>
<td>FEAR</td>
</tr>
<tr>
<td>Neutral (Facial Emotion Recognition)</td>
<td>NEUT</td>
</tr>
<tr>
<td>Emotion Labelling Total Score</td>
<td>TLAB</td>
</tr>
<tr>
<td>Emotion Discrimination Total Score</td>
<td>TDISC</td>
</tr>
<tr>
<td>Face Processing</td>
<td></td>
</tr>
<tr>
<td>Featural task (Featural processing)</td>
<td>FEAT</td>
</tr>
<tr>
<td>Scrambled faces task – difference between scrambled and non-scrambled (1st order configural processing)</td>
<td>SCRAM</td>
</tr>
<tr>
<td>Spacing task (2nd order configural processing)</td>
<td>SPAC</td>
</tr>
<tr>
<td>Fractured Faces task – proportion of correctly identified fractured faces out of those correctly identified when whole (2nd order configural processing)</td>
<td>FFT</td>
</tr>
<tr>
<td>Complete-over-part Probe advantage task (Holistic processing)</td>
<td>CPA</td>
</tr>
<tr>
<td>Mooney faces task (Holistic processing)</td>
<td>MOON</td>
</tr>
</tbody>
</table>

The performance results of the bipolar disorder patients were transformed into standardised z-scores (representing average deviation from control performance) and compared to healthy control participants and schizophrenia patients, the results are presented in Figure 25.
7.7.1 Bipolar Disorder vs. Healthy Control Performance

As shown in Figure 25, with respect to Aim A, bipolar disorder patients demonstrated impaired performance compared to healthy control participants on assessment of immediate memory, attention, total emotion discrimination and 2nd order configural face processing (assessed by the Spacing task). Bipolar disorder patients showed relatively consistent performance over the assessment methods, with performance roughly half a standard deviation below healthy control performance. The bipolar disorder participants demonstrated strengths on the visuospatial/constructional and the Zoo Map assessment, with performance at, or above, healthy control level. Weaknesses were apparent on the emotion processing tasks particularly for the recognition of happy faces (albeit not significant) and the total emotion discrimination score, performance dropped below one standard deviation of control performance for these measures.

7.7.2 Bipolar Disorder vs. Schizophrenia Performance

With respect to Aim B, the bipolar disorder group demonstrated significantly better performance than schizophrenia patients on all measures except attention, the Brixton test, the Zoo Map,
emotion recognition of happy and sad faces, the Fractured Faces task, the Scrambled Faces task and the Mooney Faces task.

7.7.3 Between-Construct Performance

With respect to Aim C, to assess the overall relationship between the three broad constructs for bipolar disorder and schizophrenia patients, the variables from each construct, i.e. neurocognition, emotion processing and face processing, were collapsed into one averaged standardised z-score representing average deviation from control performance for each construct. The averaged construct scores can be observed in Figure 26.

As indicated in Figure 26, bipolar disorder patients demonstrated impaired performance compared to healthy controls on emotion processing and face processing, however not for neurocognition. This impairment was not as severe as that of the schizophrenia patients who demonstrated significantly worse performance on each of the three constructs.

Figure 26. Performance of Bipolar & Schizophrenia Patients on Broad Constructs

* p<0.05 compared to controls  
+ p<0.05 compared to schizophrenia

Schizophrenia — Bipolar disorder

4 This data has resulted in two publications; (Gogos et al., 2009; Joshua et al., 2009)
7.7.4 Multiple Regression Analysis

With respect to Aim D, a hierarchical multiple regression analysis was conducted to examine the indirect relationship between neurocognition and emotion processing for bipolar disorder patients. Neurocognition was entered at stage one, followed by face processing at stage two. The assumption testing outlined in Chapter 6 was followed and there were no violations of the assumptions involving sample size, multicollinearity, singularity, outliers, normality, linearity, homoscedasticity, or independence of residuals.

The regression statistics are presented below in Table 26. The results indicated that bipolar patients’ performance on neurocognition and face processing significantly predicted performance on emotion processing, together explaining 30.4% of the variance ($R^2=0.551$, adj $R^2=0.252$; $F(2,27)=5.88$, $p<0.01$). Neurocognitive ability alone explained 18.8% of the variation in emotion processing. Introducing face processing explained an additional 11.6% of the variation in emotion processing. When both independent variables were included in the model, neurocognition was no longer significant. This was consistent with the proposal that neurocognitive ability affects emotion processing indirectly through its impact on face processing. Patients who had better neurocognitive ability demonstrated better face processing and hence showed better emotion processing. Not surprisingly, the most important predictor of emotion processing was face processing. As expected, patients who were better able to process facial information were better able to perceive the emotional content of a face.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Stage 1</th>
<th>Stage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Squared Semi-partial Correlation</td>
<td>Standardised Regression Coefficient</td>
</tr>
<tr>
<td>Neurocognition</td>
<td>0.187</td>
<td>0.433*</td>
</tr>
<tr>
<td>Face Processing</td>
<td>0.116</td>
<td>0.416*</td>
</tr>
</tbody>
</table>

$R^2=0.188^*$

$R^2$ Change=0.116**

$R^2=0.304$

Note: $N=30$, Dependent variable: Emotion Processing

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

These results for bipolar disorder patients can be compared to those in the previous chapter for schizophrenia patients. The model was able to explain more of the variance in emotion processing for schizophrenia patients (i.e. 49.5%) compared to bipolar disorder patients (i.e.
Furthermore, overall neurocognitive performance had more predictive value than face processing for bipolar disorder, whereas the opposite was observable for schizophrenia. This suggests that deficits in emotion processing in bipolar disorder were more relevant to neurocognitive performance than impairment in configural face processing.

### 7.7.5 Discriminant Functional Analysis

With respect to Aim E, discriminant functional analysis afforded the opportunity to explore how accurately neurocognitive, emotion processing and face processing measures were able to discriminate bipolar disorder from schizophrenia patients. Similar techniques have been used previously to differentiate schizophrenia patients from bipolar disorder patients (Dickerson et al., 2001; Tam et al., 1998), autism patients (Bolte et al., 2002), depressed and anxious patients (Srivastava & Mandal, 1990). Each of the measures related to the three constructs were entered into a discriminant function analysis for the two patient groups. If all patients were randomly assigned to one of the two groups, it would be expected only 50% of patients would be correctly classified. However, as indicated in Table 27, by using the each of the three broad constructs to aid in classification, accuracy is substantially higher than chance.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Schizophrenia</th>
<th>Bipolar disorder</th>
<th>Average</th>
<th>Wilks’ lambda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurocognition</td>
<td>72.4%</td>
<td>76.7%</td>
<td>74.6%</td>
<td>0.70; χ²(9)=18.65, p&lt;0.05</td>
</tr>
<tr>
<td>Emotion Processing</td>
<td>67.9%</td>
<td>75.9%</td>
<td>71.9%</td>
<td>0.82; χ²(6)=10.37, p=0.11</td>
</tr>
<tr>
<td>Face Processing</td>
<td>67.9%</td>
<td>75.9%</td>
<td>71.9%</td>
<td>0.67; χ²(6)=20.61, p&lt;0.01</td>
</tr>
<tr>
<td>Total</td>
<td>88.9%</td>
<td>89.3%</td>
<td>89.1%</td>
<td>0.39; χ²(21)=40.37, p&lt;0.01</td>
</tr>
</tbody>
</table>

Note: Percentages refer to proportion of correct classification. Total: All assessment methods considered together

All three constructs were able to correctly classify individuals as either schizophrenia or bipolar disorder patients with reasonable accuracy. Although no major differences between the three constructs for bipolar disorder patients, neurocognitive ability was most accurate for classifying schizophrenia patients. When all three constructs were considered together, correct classification for both groups was substantially higher. Considering the bipolar disorder patients were non-symptomatic, no exploratory correlations between cognitive performance and symptoms were performed with the bipolar disorder data.
7.8 Discussion

The current chapter revealed significant impairment in bipolar disorder patients on several non-social and social cognitive tasks. Specifically, bipolar disorder patients showed significantly lower performance compared to control participants on measures of immediate memory, attention, facial emotion discrimination and only one of the face processing measures (Spacing task). Performance did not significantly differ from controls on measures of visuospatial/construction, language, delayed memory, executive functioning (i.e. planning, switching/flexibility & planning), facial emotion recognition, or any of the other face processing tasks.

With the exception of attention, the deficits that were shown by the bipolar disorder patients were not as great as those demonstrated by schizophrenia patients. Similarly, compared to schizophrenia patients, bipolar disorder patients showed significantly better performance on measures of language, delayed memory, inhibition, recognition of neutral, angry and fearful faces as well as the Featural and CPA tasks. The two patient groups did not differ in performance on the switching/flexibility task or the recognition of happy and sad faces, however, only schizophrenia patients differed in performance compared to controls.

These results suggest that schizophrenia and bipolar disorder patient groups show qualitatively similar cognitive deficits on some aspects of cognition, but with differences in severity. In other aspects of cognition, with the exception of attention, schizophrenia patients demonstrate greater impairment than bipolar disorder patients whom show intact performance. These results are consistent with previous reviews of the literature (Daban et al., 2006). It is suggested that some cognitive deficits may be secondary to schizophrenia (i.e. those similar to deficits shown by bipolar disorder patients), while others are specific to the underlying aetiology of the disorder (i.e. those only shown by schizophrenia patients).

When all task measures were collapsed into the three broad constructs; neurocognition, emotion processing and face processing, it was revealed that both schizophrenia patients and bipolar disorder patients demonstrated impairment in emotion processing and face processing with schizophrenia patients performing significantly worse. Again, for the neurocognition domain, schizophrenia patients differed to healthy control participants and bipolar disorder patients, however, the latter two groups did not differ from one another. Although this suggests bipolar disorder patients do not exhibit generalised cognitive impairment, results indicated that the
neurocognitive ability of bipolar disorder patients was the most important predictor of emotion processing ability, over and above that of face processing. Furthermore, the effect of neurocognition on emotion processing for bipolar disorder appeared more direct than for schizophrenia patients.

The results indicated that for bipolar disorder patients, neurocognitive ability explained more of the variance in emotion processing than did face processing. Although the bipolar disorder patients did show deficits in face processing, the degree of impairment was relatively consistent across the different tasks. In contrast, the schizophrenia patients showed particular impairment on face processing tasks that required perception of configural information. Furthermore, the effect of neurocognitive ability on emotion processing was more indirect, mediated by face processing; for schizophrenia patients face processing explained a greater proportion of the variance in emotion processing than did neurocognition. The results suggest that deficits in emotion processing were more relevant to neurocognitive performance for bipolar disorder patients, and more relevant to face processing for schizophrenia patients. Schizophrenia patients did show greater impairment in configural face processing than bipolar disorder patients. This is consistent with the literature on lower-order perceptual processing in the two disorders. While schizophrenia patients tend not to recognise the holistic, Gestalt qualities of a visual scene and utilise more bottom-up featural processing strategies, this does not appear to be the case for bipolar disorder patients who, like controls, use holistic processing strategies where available. This may result in less impairment in basic configural face processing; indicating emotion processing impairment is less of an underlying lower-order perceptual problem and more of a higher-order, or top-down problem in bipolar disorder. For example, the substantial attentional deficits in bipolar disorder may be particularly influential on emotion processing. Interestingly, the patients in the current study were euthymic so the results presented are not influenced by mood symptoms. This suggests that, like schizophrenia, bipolar disorder does have residual cognitive abnormalities during periods of wellness.

The results of the current chapter also indicated that a combination of neurocognitive, emotion processing and face processing tasks can provide a useful means to differentiate schizophrenia patients from bipolar disorder patients, with accuracy of classification approaching 90%. Although there are similarities, as discussed above in 7.1.1, schizophrenia and bipolar disorder are distinct conditions. The current data further indicates the social and non-social cognitive profiles of the two disorders are different. Although differentiation of cognitive functioning has
potential to help avoid misdiagnosis, it must be noted the assessment methods used did elucidate substantial variability within group performance, and thus, caution must be made not to overemphasise the use of such theoretical, statistical techniques and the ability to translate to clinical practice.

7.8.1 Limitations

There were several limitations with the current study worthy of note. Firstly, the number of psychotic episodes for the two patients groups was not assessed. Therefore, it is possible that the two patient groups differed in the frequency and/or severity of psychosis. Likewise, it was not determined that all bipolar disorder patients had indeed experienced psychotic events at all. Secondly, as indicated, more of the schizophrenia patients in the current work were unwell which may have contributed to exacerbate deficits. Future research could attempt to match the phase of illness of both groups.

7.9 Summary

In summary, the bipolar disorder patients showed impairment on some but not all aspects of social and non-social cognition compared to healthy controls. This impairment was as severe as those observable in schizophrenia patients for some, but not all aspects of social and non-social cognition. These results suggest some of the deficits demonstrated by schizophrenia patients may be specific to the disorder, whereas others may be common to other diagnostic groups with similar clinical characteristics, for example psychotic experience, limited education, social isolation, medication, and hospitalisation.
Chapter 8  Conclusion

This thesis reports on the relationship between neurocognitive ability, facial emotion processing and face perception in schizophrenia, with a particular investigation into the role of configural information for face perception. The investigation was based on the cognitive performance of 29 individuals who had been diagnosed with schizophrenia and 29 healthy control individuals (Chapter 2). This research began broadly, with an assessment of basic non-social neurocognitive performance, including memory, language, attention, visuospatial ability and executive functioning (Chapter 3). The focus then shifted to social cognitive ability with investigation into facial emotion processing including labelling and discrimination of universally recognised facial expressions (Chapter 4). Narrowing further, the thesis then examined the underlying processing styles pertinent to the perception of facial information. This included featural processing, first-order configural, second-order configural and holistic processing (Chapter 5). These three chapters afforded the opportunity to integrate the findings together and assess how neurocognition and basic face perception impact upon emotion processing (Chapter 6). To explore the diagnostic specificity of impairment, the investigation went on to assess 30 individuals who had been diagnosed with bipolar affective disorder on the same cognitive battery as the other two participant groups (Chapter 7).

8.1  Important Findings from this Investigation

The results from Chapter 3 indicated that schizophrenia patients demonstrated a generalised neurocognitive deficit. With only one exception (i.e. Zoo Map planning), performance of the schizophrenia patients was significantly lower on all task measures compared to controls (i.e. RBANS immediate memory, delayed memory, visuospatial / constructional, language, attention, HSCT response initiation and inhibition, and Brixton Test cognitive flexibility). These findings concurred with the previous literature that had used these measures. Impairment on some of these tasks correlated with negative symptom severity.

Chapter 4 revealed that schizophrenia patients showed impairment in the labelling and discrimination of the universally recognised emotional expressions; sadness, fear, anger and neutrality, however, no impairment for happiness. It was considered that the intact performance for ‘happy’ facial expressions may be a product of the difficulty level of happy facial expressions
compared to the more negative facial expressions such as sadness, fear and anger. It was proposed that the degree of difficulty related to how much overlap there was in featural information, i.e. ‘action units’ between that emotion and other emotions. This argument indicates that the more two emotional expressions share similar featural shaping, e.g. down-turned mouth, the more they would rely on other processing styles, i.e. configural processing, thus rendering them more difficult. Schizophrenia patients showed particular deficits on the negative emotions, perhaps because of the overlap in featural information, and consequential associated difficulty level. Control participants appear to utilise other processing strategies, i.e. configural processing, to aid in emotion processing, however, it was predicted schizophrenia patients do not utilise such strategies as profitably. To investigate this notion, a series of configural processing tasks were developed and performance was assessed.

Chapter 5 indicated that schizophrenia patients did indeed demonstrate impairment on tasks requiring second-order configural information, and thus were not as disadvantaged as controls when this configural information was disrupted. The configural face processing deficits shown by the schizophrenia patients in the current investigation are consistent with the perceptual organisation literature in schizophrenia. Schizophrenia patients appear to favour more fragmented and time consuming, bottom-up or approaches for perception over the top-down, Gestalt approach (John & Hemsley, 1992; Peters et al., 2002; Silverstein et al., 2000). Bottom-up processing styles do not always lead to impaired performance however. In an elegant study by Place and Gilmore (1980) schizophrenia patients showed a bottom-up processing style to be advantageous in certain circumstances. Participants were required to count the number of lines presented in differing spatial arrangements. Control participants outperformed schizophrenia patients when the organizations were simple and grouping principles were available, hence allowing efficient top-down processing. However, as the complexity of the arrangements increased, control performance deteriorated. According to Place and Gilmore initial attempts to use top-down processing strategies failed and participants were then required to revert back to bottom-up processing. In comparison, performance of the schizophrenia patients remained stable throughout the conditions, as the same bottom-up strategies were used for all conditions. The schizophrenia patients in fact showed superior performance to the control participants for the most difficult arrangements as they did not have to switch processing strategies. This unique finding is consistent with some of the findings from the current body of work. For example, on occasions when configural facial information was disrupted, by either inversion or fracturing, the performance of control participants deteriorated more than that of the schizophrenia
patients. Based on these findings it is appropriate to suggest that schizophrenia patients may show impaired top-down processing. Further, due to the configural nature of facial information, which relies on such top-down processes for recognition, schizophrenia patients exhibit impairments in face perception. Therefore, the impairment may not be specific to faces per se, but on stimuli classes that are particularly dependent upon configural information.

An integration of findings presented in Chapter 6 revealed correlations between neurocognitive, emotion processing and face processing task performance for schizophrenia patients. Interestingly, although neurocognition and face processing both explained a significant proportion of the variance in emotion processing, the effect of neurocognition was indirect and mediated by face processing. Interestingly, there are increasing number of discussions on the effect of bottom-up perceptual processing on higher-order cognitive (social and non-social) ability (Javitt, 2009; Uhlhaas & Mishara, 2007). The role of basic perceptual systems is now considered as a contributor to neurocognitive dysfunction in schizophrenia, both in auditory and visual faculties. Chapter 6 of this thesis highlights how lower-level functioning impacts upon higher cognitive abilities, however, it is important to investigate a step further back in this hierarchy of processing. For example, Javitt discusses the link between lower level and higher level cognitive functioning in relation to the neurotransmitter systems relevant to schizophrenia. Specifically, the glutamatergic system has been implicated in low level visual perception dysfunction (Kwon et al., 1991). Thus, N-methyl-D-asparate (NMDA) receptor dysfunction in schizophrenia may be mediating the configural processing deficits that were demonstrated in this thesis. Clearly, this is an important area for future investigations, and consequently the current author and associated laboratory is conducting a project investigating configural face processing in individuals under a sub-anaesthetic dose of ketamine, a NMDA receptor antagonist.

Chapter 7 addressed the diagnostic specificity of neurocognitive, emotion processing and face processing impairment shown in schizophrenia by comparing the performance to a group of bipolar disorder patients. It was revealed that patients of both disorders demonstrate qualitatively similar neurocognitive performance although differ in severity with schizophrenia patients showing the greatest impairments. For the face processing tasks, bipolar disorder patients demonstrated impairment on only one of the measures (slightly over half a standard deviation from healthy control performance), whereas the schizophrenia patients demonstrated much more severe impairment on three of the measures. Furthermore, the neurocognitive deficit in bipolar disorder appeared to impact emotion processing ability in a more direct way.
compared to the mediated effects observable in schizophrenia. For schizophrenia patients, impairment in facial emotion processing appeared to be more related to configural face processing deficits, whereas in bipolar disorder, impairment appeared to be more related to neurocognitive problems.

8.2 Implications for Diagnosis

As discussed, neurocognitive impairment is being considered for inclusion in future diagnostic criteria used for schizophrenia i.e. the DSM-V. The results presented in this thesis are consistent with this recommendation as they provide further evidence that schizophrenia patients show extensive cognitive impairment over a range of functions compared to both healthy controls and other diagnostic groups. Furthermore, this work indicates that cognitive impairment can be reliably demonstrated using a relatively short cognitive battery that requires minimal administrator training.

The current body of work also highlights the importance of potentially including an assessment of social cognitive ability within diagnostic criteria. While it is not suggested neurocognitive and social cognitive assessment methods will be suitable to provide diagnostic information when used alone, such assessment used in conjunction with existing criteria could be advantageous. Clearly, rigorous psychometric testing would be required for any social cognitive measures to ensure reliability, validity and normative performance.

As discussed in the previous chapter, schizophrenia and bipolar disorder show a distinct overlap in clinical presentation. So much so that some debate that schizophrenia and bipolar disorder should be considered part of the same spectrum of disorder. The findings from the current thesis indicate that schizophrenia patients showed significant lower-order perceptual deficits whereas bipolar did not. This dissociation in performance suggests a level of diagnostic specificity, thus providing a contribution to the spectrum debate.

8.3 Implications for Treatment

Investigations such as the current body of work, will aid in determining which social cognitive deficits should be targeted for remediation (Mandal et al., 1998). Furthermore, elucidating the relationship between face processing, facial emotion processing and neurocognition in
schizophrenia may influence social cognitive remediation strategies. For example, the current results demonstrate that both neurocognition and social cognition are appropriate targets for remediation of social cognition. Alternatively, given the indirect influence of neurocognition, one may prefer to establish a cognitive remediation package that focuses on improving configurational processing strategies in schizophrenia.

8.4 Limitations of this Investigation

There were several notable limitations to the thesis relating 1) to participant characteristics and assessment and 2) to task characteristics. Firstly, there was a gender imbalance across participants from each of the three groups. Although provisions were made to explore gender as an influential factor within the analysis, considering there is research to suggest there may be gender differences in emotion processing (Montagne et al., 2005; Thayer & Johnsen, 2000), future investigations should attempt to include equal numbers of males and females across groups.

Furthermore, there were a number of clinical characteristics that could have been better matched. The current study did not make note of the number of psychotic episodes of either clinical group, nor were clinical groups matched for symptom severity. It was also not possible to determine the role of medication on performance because of the variety of medications and dosages taken by the patients involved in the current body of work. The assessment of functioning within the current study design, i.e. GAF, only gave a very general overview of functioning level. In retrospect, the investigation would have benefited from a more in-depth analysis of functioning with focus on community and social integration.

There were several limitations relating to the task characteristics. Firstly, there were some ceiling effects observable for two subtests of the RBANS (Picture Naming and List Recognition) and the Scrambled Faces task. Additionally, it has been consistently demonstrated that schizophrenia patients show deficits on assessment of planning ability, however, the Zoo Map test did not appear sensitive enough to reveal these deficits and thus may not have been an appropriate task choice.

As indicated, all of the face processing tasks included in the current work were experimental and used for the first time, consequently, psychometrics were not available. This notwithstanding, no
task had ceiling or floor performance (with exception of Scrambled Faces Task) and did reliably reveal group differences, where predicted. As a result of the novel nature of the tasks however, the findings from this thesis require replication using the same methodology.

A further limitation involves the total time taken to complete the whole testing session. Although the task order was randomised across subjects, some individuals may have become tired or less motivated towards the end of the session. This must be considered a limiting factor to any such cognitive testing.

Finally, it must be noted that face processing and facial emotion processing reflect just one small aspect of social cognition. In addition to auditory emotion processing i.e. prosody, and body language, there are many other factors such as social perception, theory of mind and attributional style that are considered social cognitive functions and may also greatly impact on the social deficits observable in schizophrenia. An integration of the different impairments across sensory modalities and levels of processing will be crucial to an understanding of social cognition in schizophrenia.

8.5 Important Recommendations for Future Research

Many questions still remain regarding the role of configural processing in the social cognitive deficits demonstrated by schizophrenia patients. For example, the literature would benefit from further investigation into ‘the other-race effect’, and the role of ethnicity on face processing in schizophrenia. Only one study has explored this in schizophrenia, revealing a typical, healthy ‘other-race effect’ (Pinkham et al., 2008). However, considering the role configural information in this effect and the growing evidence to suggest impaired configural processing in schizophrenia, the race effect should be explored in greater detail.

Further investigation into configural processing should incorporate dynamic face stimuli within experimental designs. For both healthy controls and schizophrenia patients, the implication of configural change within the ‘motion’ of facial expression is clear. For example, the change in spacing and distances between features is critical as a facial expression changes from one emotion to another or from a subtle to extreme expression. The literature into dynamic face processing in schizophrenia is growing as is the literature into configural face processing in schizophrenia; thus some merger of the two areas would be valuable.
Future investigations should also explore the hypothesis that some emotional expressions rely more on configural processing styles, i.e. sadness, anger, fear, and others rely more on featural processing styles, i.e. happiness. An investigation into potential differential FIEs (or other methods of configural disruption) over these different emotions would help an understanding in face processing for healthy controls as well as clinical populations.

Future research could utilise the model of face processing proposed in Chapter 6 to explore the relationship between neurocognition, emotion processing and face processing in schizophrenia patients at different stages of illness course i.e. acute inpatients, as well as bipolar disorder patients in manic or depressed phases of illness.

8.6 In Summary

This thesis has provided extensive empirical data that presents an important insight into the interaction of basic information processing strategies, in the specific domain of faces, and other cognitive abilities in schizophrenia. In 1983, Goldstein (1983) made a prediction that researchers for years to come would investigate face processing, and that this research would make clear contributions to understanding how facial information influences behaviour. As evidenced by this thesis and the growing literature on configural processing in schizophrenia (Baudouin et al., 2008; Chambon et al., 2006; Chen et al., 2009; Chen et al., 2008; Schwartz et al., 2002; Shin et al., 2008), these predictions were accurate. Without such theory driven, specific cognitive investigation, untangling the aetiology of emotion face processing deficits in schizophrenia would not be possible. This thesis has contributed to an understanding of the social burden experienced by schizophrenia patients, and has demonstrated how social and non-social cognitive dysfunction may contribute to social isolation. Investigations such as this ultimately aim to improve the quality of life and well being of schizophrenia patients, by increasing scientific awareness and knowledge in the field.
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Appendices

Appendix 1: Newspaper Advertisement for Recruitment of Control Participants

CONFIGURAL PROCESSING STUDY

Configural processing refers to the way we perceive the arrangement of parts that gives a shape its basic form. The purpose of this project is to further our understanding of how people view faces and recognize different emotions. Previous research projects have shown that patients with schizophrenia may focus on certain parts when viewing a face, whereas others view the face as a whole. As there are many symptoms of schizophrenia that have an emotive and social quality, it is important to investigate how patients with schizophrenia perceive emotional content. We will therefore be investigating different perceptual techniques of visual processing with an emphasis on emotional content.

Key points to note

- Participation involves attending a research session at the Mental Health Research Institute in Carlton.
- It is expected that this session will take approximately 2½ hours.
- If required, we will assist you with transport arrangements to and from research venues.
- Participants will be reimbursed $30 after participation is complete.

Who are we looking for?

- Individuals with a diagnosis of schizophrenia
- Individuals with a diagnosis of bipolar disorder who are currently euthymic (i.e. currently stable, not currently experiencing a manic or depressive episode).
- Individuals in the general public with no history of a psychiatric or neurological illness.

Exclusion criteria

- History of a major neurological condition
- History of intellectual disability
- History of a major head injury – with loss of consciousness
- Severe substance abuse
- Experience of ECT over the past 12 months
- English not as a first language

For further information or to express your interest please contact Nicki on 8344 1853 or email: njoshua@mhri.edu.au

Thank you for your assistance!
An Investigation into Configural Processing and Emotion Perception in Schizophrenia

Participant Information/Plain Language Statement

Principal Researchers: Ms Nicole Joshua, Associate Professor Susan Rossell
Associate Researcher: Professor David Castle

- Your Consent
You are invited to take part in this research project. This Information Sheet contains details about the project, and explains to you as openly and clearly as possible all the procedures involved. Feel free to ask any questions about the project. All individuals will be given the information sheet and will have at least 24 hours to decide whether or not to participate. Once you understand what the project is about and if you agree to take part in it, you will be asked to sign the Consent Form. You will be given a copy of the Participant Information and Consent Form to keep as a record. This project has been approved by The University of Melbourne Human Research Ethics Committee (HREC).

- What is the research project about?
Configural processing refers to the way we perceive the arrangement of parts that gives a shape its basic form. The purpose of this project is to further our understanding of how people view faces and recognize different emotions. Previous research projects have shown that patients with schizophrenia may focus on certain parts when viewing a face, whereas others view the face as a whole. As there are many symptoms of schizophrenia that have an emotive and social quality it is important to investigate how patients with schizophrenia perceive emotional content. We will therefore be investigating different perceptual techniques of visual processing with an emphasis on emotional content. For example, we will be comparing when people process faces just by the features of the face (known as featural processing) compared to when people process faces by the specific arrangement of the features (known as configural processing).

- Who are the researchers?
This project is being conducted by Miss Nicole Joshua, who is a PhD candidate enrolled through the Department of Psychiatry at The University of Melbourne. The project is being supervised by Associate Professor Susan Rossell who is a cognitive neuropsychologist and Head of Cognitive Neuropsychiatry at the Mental Health Research Institute (MHR). Professor David Castle is an associate researcher contributing to the project. Professor Castle is currently Chair of Psychiatry at St Vincent's Hospital and The University of Melbourne as well as an Honorary Professorial Research Fellow at MHR.

- What sort of people are we looking for?
We are looking for three types of people between 18-65 years of age to be part of this study:

* Individuals with a diagnosis of schizophrenia

* Individuals with a diagnosis of bipolar disorder who are currently euthymic (i.e. currently stable, not currently experiencing a manic or depressive episode).

* Individuals in the general public who have no history of mental or neurological illness and speak English as their first language.
What will you be asked to do?
You will be invited to attend a research session to be completed at the Mental Health Research Institute (MHRi) in Carlton. The research session will be split into two parts and will take approximately 3½ hours in total. Firstly you will be asked to sign the consent form to indicate you have read this information and agree to participate in the study. You will also be asked if you give permission for the researchers to contact your psychiatrist/case manager/doctor to clarify points regarding your medical history; this is optional and if you do not wish to give permission for contact you do not have to and will still be able to participate.

Interview (part 1)
We will start with a brief interview because we would like to know some background information about you. These questions will be straightforward and there are no right or wrong answers. This part will go for approximately 1 hour. This part involves screening questions and helps us to determine if you are eligible to participate in the study. If we determine you are not eligible, your participation will cease here, at which point you may be advised to consult your health care provider.

Cognitive battery (part 2)
After the interview, if we determine that you are eligible to participate, you will be asked to complete a series of picture tasks on a computer. These tasks will require you to, decide on the emotions of peoples faces; decide whether you recognize certain faces; and make judgments about pictures and shapes. Note, there are no right or wrong answers for many of the tasks, therefore you will not receive a copy of the specific results, you will however, have a chance to ask any questions and discuss the rationale behind the tasks if you choose to do so. This part will go for approximately 2½ hours.

You will receive $30 once your participation is complete.

What are the possible risks and discomforts?
There are no predicted risks associated with this project. During the interview you will be asked about any history of psychosis with yourself or within your family. The interview questions are required so we can gain a full understanding of your experiences. They are not designed to make you feel uncomfortable, however, if you do feel uncomfortable you do not have to answer and if you choose to do so, may withdraw from the project at any time. If you become tired during the testing you may request a rest or break at any stage.

What happens to the information?
All the information you give to us will be treated in the strictest confidence and used only for research purposes. Your name will not be used and a code number will identify all participants. The information will be kept in a locked cabinet, or on a computer with a password, and only people involved in the study will have access, all data will be destroyed after a period of 5 years. We hope that the findings from this project will be presented at scientific meetings and in scientific journals, only group results will be published. Confidentiality of information is subject to legal limitations.

Where can I get further information?
Should you require any further information on the project, or if you have any concerns, please do not hesitate to contact either of the principle investigators; Ms Nicole Joshua on (03) 8344 1853 or Associate Professor Susan Rossell on (03) 8344 1821. If you have any concerns about the conduct of this project, please contact The Executive Officer, Human Research Ethics, The University of Melbourne, ph: (03) 8344 2073; fax (03) 9347 0739.

What happens if I don’t want to take part or want to stop participating in the study?
You do not have to take part in this study. If you do choose to take part, you can change your mind at any time during the session and all unprocessed material relating to your participation will be kept completely confidential.

We thank you for your time and for helping us in our research.
### Appendix 3: Overview of Results for the Featural-Spacing Manipulation Tasks

<table>
<thead>
<tr>
<th>Main Effects</th>
<th>Accuracy (% correct)</th>
<th>Response Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (schizophrenia, control)</td>
<td>$p &lt; 0.001$</td>
<td>n.s.</td>
</tr>
<tr>
<td>Condition (featural, spacing)</td>
<td>$p &lt; 0.001$</td>
<td>$p &lt; 0.01$</td>
</tr>
<tr>
<td>Orientation (upright, inverted)</td>
<td>$p &lt; 0.001$</td>
<td>n.s.</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition x Orientation</td>
<td>$p &lt; 0.01$</td>
<td>$p &lt; 0.01$</td>
</tr>
<tr>
<td>Condition x Group</td>
<td>$p &lt; 0.05$</td>
<td>$p &lt; 0.01$</td>
</tr>
<tr>
<td>Orientation x Group</td>
<td>n.s.</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Condition x Orientation x Group</td>
<td>n.s.</td>
<td>$p &lt; 0.01$</td>
</tr>
</tbody>
</table>

n.s. (non-significant)

### Appendix 4: Overview of Results for the CPA Task

<table>
<thead>
<tr>
<th>Main Effects</th>
<th>Accuracy (% correct)</th>
<th>Response Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (schizophrenia, control)</td>
<td>$p &lt; 0.001$</td>
<td>n.s.</td>
</tr>
<tr>
<td>Orientation (upright, inverted)</td>
<td>$p &lt; 0.001$</td>
<td>n.s.</td>
</tr>
<tr>
<td>Condition (whole, part)</td>
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<tr>
<td>Feature (eyes, nose, mouth)</td>
<td>$p &lt; 0.001$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group x Orientation</td>
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<td>n.s.</td>
</tr>
<tr>
<td>Group x Condition</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>Group x Feature</td>
<td>$p &lt; 0.05$</td>
<td>n.s.</td>
</tr>
<tr>
<td>Condition x Orientation</td>
<td>$p &lt; 0.01$</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>Orientation x Feature</td>
<td>$p &lt; 0.01$</td>
<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>Condition x Feature</td>
<td>$p &lt; 0.05$</td>
<td>n.s.</td>
</tr>
<tr>
<td>Orientation x Condition x Group</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>Orientation x Feature x Group</td>
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<td>n.s.</td>
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<tr>
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<td>n.s.</td>
</tr>
<tr>
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<td>n.s.</td>
</tr>
<tr>
<td>Condition x Orientation x Feature x Group</td>
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<td>$p &lt; 0.05$</td>
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</table>

n.s. (non-significant)

### Appendix 5: Overview of Results for the Mooney Faces Task

<table>
<thead>
<tr>
<th>Main Effects</th>
<th>Accuracy (% correct)</th>
<th>Response Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (schizophrenia, control)</td>
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<td>$p &lt; 0.01$</td>
</tr>
<tr>
<td>Condition (face, non-face)</td>
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<td>$p &lt; 0.05$</td>
</tr>
<tr>
<td>Orientation (upright, inverted)</td>
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<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group x Condition</td>
<td>n.s.</td>
<td>$p &lt; 0.01$</td>
</tr>
<tr>
<td>Orientation x Group</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>Condition x Orientation</td>
<td>$p &lt; 0.001$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Condition x Orientation x Group</td>
<td>n.s.</td>
<td>$p &lt; 0.05$</td>
</tr>
</tbody>
</table>

n.s. (non-significant)