AN INVESTIGATION OF SCHIZOTYPY, 'THEORY OF MIND' AND 'WEAK CENTRAL COHERENCE'

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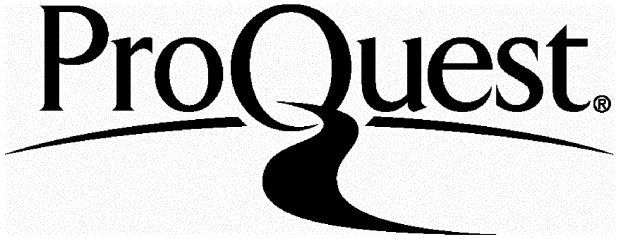

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ABSTRACT

This study investigated two psychological models of schizophrenia using the schizotypy paradigm, which assumes a continuum of psychosis-proneness in the normal population.

Model 1

C. Frith's (1992) cognitive neuropsychological model of schizophrenia arose from research in autism which showed that autistic people have impairments in 'theory of mind' (ToM), the ability to represent the mental states of oneself and others. In extending this work into schizophrenia, C. Frith suggested that many psychotic symptoms are also associated with impaired ToM. On the basis of this model, it was predicted in the present study that high total scores on a standard measure of schizotypy within the normal population, would be associated with poor performance on tests of ToM. In line with C. Frith's (1992) model, it was further expected that the poorest ToM would be associated with high scores for schizotypal traits analogous to 'behavioural signs' of schizophrenia (such as social withdrawal, affective flattening or inappropriate speech and behaviour). Schizotypal traits analogous to the 'positive symptoms' of schizophrenia (e.g. delusions and hallucinations) were expected to be more weakly associated with impaired ToM.

Sixty-two normal volunteers completed a standard schizotypy questionnaire (the Oxford-Liverpool Inventory of Feelings and Experiences; O-LIFE), and a standard story test of

ToM. A set of 'physical' control stories was also administered to control for variation in participants' ability to imagine abstract or hypothetical states of affairs, and to reason and make inferences. Subjects also completed the Cognitive Estimates Test to control for differences in executive function, and the Quick Test to control for verbal IQ.

Only limited support was found for C. Frith's (1992) model. Individuals scoring high on total schizotypy did not differ significantly in ToM ability from those whose total schizotypy was low. Contrary to C. Frith's model, there was no association between poorer ToM and schizotypal traits analogous to the behavioural signs of schizophrenia. However, schizotypal traits analogous to positive symptoms were associated with poorer performance on the ToM task, as predicted by the model. There was no relation between schizotypy and scores on the 'physical' stories, executive function, or verbal IQ tests, and it was concluded that positive schizotypal traits in the normal population are associated with difficulties representing mental states.

Discussion focused on the differences between these results and the predictions from C. Frith's model. The present data were also contrasted with those of Langdon & Coltheart (1999), whose findings did broadly support the theoretical predictions. It was concluded that differences between the present results and those of Langdon and Coltheart were largely a reflection of differences between the schizotypy questionnaires used in the two studies. It was also argued that a strong association between poor ToM and 'behavioural signs' may only appear in studies of schizophrenic patients, and that the main effect in

studies of schizotypy in normals is the association between poorer ToM and scores for positive schizotypal traits.

Model 2

U. Frith (1989) suggested that autistic people have a cognitive style of 'weak central coherence' (WCC), whereby they focus on detail at the expense of gestalt or overall meaning. By analogy with C. Frith's (1992) extension of the ToM model from autism into schizophrenia, Pickup (1997) argued that psychotic symptoms may be associated with WCC, and found some empirical support for this in a study of schizophrenic patients. On the basis of Pickup's hypothesis, it was predicted in the present study that high scores for total schizotypy in the normal population would be associated with WCC, as revealed by the ability to accurately and quickly find hidden objects in embedded figures stimuli. It was further expected that the best task performance would be associated with schizotypal traits analogous to autistic features, i.e. social withdrawal, affective flattening, or inappropriate speech and behaviour.

Sixty four normal volunteers completed the O-LIFE schizotypy questionnaire and a new embedded figures test (EFT) designed for adults by Pickup (1997). Raven's Advanced Progressive Matrices were also administered to control for spatial IQ. The tests were given in the same session as the measures of theory of mind discussed above.

No support was found for the theoretical predictions. There were no differences in performance on the EFT between participants divided into high and low total schizotypy groups, and none of the individual dimensions of schizotypy were significantly correlated with task performance. It was concluded that no support was found for Pickup's (1997) suggestion that the WCC account of autism can be extended into schizophrenia. The implications of this finding and suggestions for future work were discussed.

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CHAPTER 1: INTRODUCTION

The study detailed in this thesis explores the relationship between schizotypal traits in the normal population and two cognitive abilities, abnormalities in which have been linked to both autism and schizophrenia. The first of these abilities is 'theory of mind', and the second is the cognitive style of 'weak central coherence'. The first section of this Introduction will discuss what is meant by 'schizotypy'and how it can be measured. In the second section it will be shown how the schizotypy construct underlies a useful methodology in the normal population for investigating models of psychosis, and a brief review of relevant studies will be presented. In section 1.3, the focus will narrow to one particular model of psychosis, namely C. Frith's (1992) hypothesis that impaired theory of mind (ToM) underlies many of the symptoms of psychotic illness. ToM will be defined in the context of studies on normal and autistic people. Frith's model will be discussed and studies of ToM in schizophrenic patients will be reviewed. The rationale will then be presented for the first part of the present study, in which the relation between ToM and schizotypy is investigated in the normal population. In section 1.4 of the Introduction the literature on 'weak central coherence' in autism will be reviewed, and links made to related phenomena in schizophrenia. The rationale will be presented for the second part of the present study in which the relation between 'weak central coherence' and schizotypy is investigated.

1. 1 SCHIZOTYPY AND ITS MEASUREMENT

Definitions of schizotypy

The term 'schizotypy' refers to the notion that there is a broad spectrum of experiences and behaviours which can be classified as 'psychotic' or psychosis-related. Full-blown psychotic illnesses such as schizophrenia lie at the extreme end of this spectrum, but less extreme are more subtle manifestations such as the paranoid, schizoid or schizotypal (Cluster A) personality disorders in DSM-IV (American Psychiatric Association, 1994), or personality traits in healthy individuals such as belief in telepathy or magic (see Claridge, 1987; 1997; Claridge & Beech, 1995). The notion of a psychosis continuum originated with Bleuler (1911), who coined the term 'latent schizophrenia' to describe individuals who showed 'strange or eccentric behaviours' but did not manifest a full-blown schizophrenic illness. Meehl (1962) went on to suggest how the concept of schizotypy could be linked to genetic predisposition and the risk for schizophrenic breakdown. As discussed by Claridge (1997), there are three main views as to the precise nature of the psychosis spectrum:

a) The quasi-dimensional model

This has been widely adopted by schizotypy researchers in the USA (e.g. Lencz *et al.*, 1995; Meehl, 1962) and is based primarily within the medical model and psychiatric diagnosis, so that psychotic illnesses lie at the severe end of the spectrum and Cluster A personality disorders at the less severe end. The emphasis of this model is on illness,

so that all individuals along the spectrum are assumed to have an underlying disease process of varying severity. As a result, there is no place in the model for the personality traits and individual differences of healthy people.

b) Eysenck's fully-dimensional model

H. Eysenck (1960) proposed that all 'psychotic' experience lies on a continuum, with normal personality traits at one end and full-blown psychosis at the other. As Claridge (1997) notes, this model does not incorporate any discontinuity between normal health and mental illness, as there is no clear demarcation at the point where normal personality traits become symptoms of illness.

c) Claridge's fully-dimensional model

Claridge (1987) argued that it is crucial to make a sharp distinction between normal personality traits and symptoms of illness. Thus, the former can be seen as sources of healthy variation which may act as predisposing factors to illness only when additional factors (e.g. physical or environmental stressors) are present. In contrast, symptoms are seen as qualitatively distinct and indicate that an individual has crossed to the domain of mental disorder. Claridge (1987) therefore proposed a fully-dimensional model which includes (like Eysenck's) all degrees of 'psychotic' experience, but incorporates a discontinuity between healthy individuals and those with a psychiatric diagnosis. Healthy individuals are seen to vary along a continuum, with personality traits, cognitive style, nervous system factors and genetic variation all contributing to

the person's degree of schizotypy. At a point of discontinuity (where the influence of external factors is important), this healthy continuum transfers into a pathological continuum which covers the range of severity of psychiatric disorder from mild Cluster A personality disorders to full-blown psychotic illnesses.

This model has achieved wide acceptance in the research community (especially in Europe) because, as well as including important aspects of the medical model, it explicitly allows for the widely-replicated finding that in the normal healthy population a broad range of scores is found on standard questionnaire measures of schizotypy (discussed below). Claridge's model also stresses the importance of the interaction between predisposing and environmental factors in the transition from health to mental illness, and in this respect accords with the widely-accepted 'diathesis-stress' model of schizophrenia (e.g. Gottesman, 1991). Claridge's model will be used as a basis for the research carried out in this thesis, as it explicitly considers schizotypy within the normal population, from which the sample discussed here is drawn.

Measurement of schizotypy

Many self-report questionnaire measures of schizotypal traits have been developed over the past thirty years, and as reviewed by Mason *et al.* (1997), these generally fit either the quasi-dimensional or fully-dimensional approaches to schizotypy research. In the following sections, a brief review of some of the most commonly used measures will be presented. The newly developed O-LIFE questionnaire (Mason *et al.*, 1995), which is used in the present study, will also be discussed.

Quasi-dimensional approaches

In this domain, one type of measure deserves special mention. In the 1970s and 80s, the Chapman research group in the USA devised a number of scales to detect mild forms of 'psychotic' experience such as 'perceptual aberration', 'magical ideation' and 'social anhedonia' (see Mason *et al.*, 1997, for a review). In line with the medical model, these questionnaires were strongly based on psychiatric symptom inventories and emphasised people's experience of (rather than just belief in) phenomena such as thought transmission. As discussed by Mason *et al.*, this may explain why most normal, healthy people tend not to endorse many of the Chapman items and why the scores of most normals are very similar on these scales.

The Chapman group published the first longitudinal study (Chapman *et al.*, 1994) to investigate the hypothesis that high schizotypes are at higher risk than lower schizotypes of developing psychosis later in life. Chapman *et al.* followed up 508 college students who they had selected 10 years previously from an initial cohort of 7800 students who all completed schizotypy questionnaires. Chapman *et al.* found that, as expected, high initial scores for perceptual aberration, magical ideation and social anhedonia predicted a greater likelihood of subsequent psychoses than lower scores on these scales. As the Chapman scales are set firmly within the quasi-dimensional (medical) model of schizotypy, it is possible that the initial high scorers on the scales were individuals meeting at least some of the DSM criteria for Cluster A personality disorders. An important study still remaining to be done, therefore, would use similar methodology to investigate the predictive validity of fully-dimensional

measures (e.g. those discussed below), which assess schizotypy in healthy individuals who do not necessarily meet any DSM criteria. As discussed earlier, it is thought that high scorers on these measures are vulnerable to psychotic illnesses later in life if they experience additional factors such as environmental or physical stressors.

Fully-dimensional approaches

As part of his model of individual differences, H. Eysenck devised the P-scale as a measure of Psychoticism in normals (see Eysenck & Eysenck, 1991). As discussed by Mason *et al.* (1997), there are a number of problems in adopting the P-scale as a measure of schizotypy, not least being its strong emphasis on antisocial and impulsive personality traits, with less consideration of typical 'psychotic' features such as paranoia or unusual beliefs. Claridge & Broks (1984) therefore devised a questionnaire whose items were based on DSM-III criteria for schizotypal personality disorder, but which were cast into a less pathological form than the DSM items in order to sample normal experience. The resultant questionnaire was the STA, which formed part of a larger measure (the STQ). The STA is shown in Appendix 1 and was used in the study described in this thesis as a screening measure to classify normal subjects as 'high', 'average' or 'low' schizotypy.

Components of schizotypy

The various schizotypy scales include a range of questions covering many different aspects of normal experience and behaviour derived from descriptions of 'psychotic'

presentations in schemes such as the DSM. A number of studies have now been published in which several different scales were given to a sample of individuals, and the data factor analysed to see whether groupings of schizotypal traits emerged (see Claridge & Beech, 1995, and Mason *et al.*, 1997, for reviews). In the largest study to date, Claridge *et al.* (1996) analysed data from a collected sample of 1095 normal individuals who completed the 'Combined Schizotypal Traits Questionnaire' (CSTQ). This included the Eysenck Personality Questionnaire (EPQ), the STA and the Chapman scales, as well as more than 10 other measures of schizotypal features.

Claridge *et al.*'s analysis produced a 4-factor solution, showing clearly that schizotypy does not comprise a unidimensional set of traits. The first factor included unusual perceptual experiences, thinking styles and beliefs and loaded heavily on the Chapman scales and the STA. The second factor was labelled 'cognitive disorganization with anxiety' as it loaded on items covering social anxiety and/or cognitive traits such as attentional difficulties and distractibility. The third factor was termed 'asocial behaviour' as it included traits of impulsivity and disinhibition and loaded heavily on Eysenck's P-scale. Finally, Claridge *et al.*'s fourth factor was labelled 'introvertive anhedonia', as it included features such as solitariness and lack of feeling. As several workers have noted that the EPQ was not specifically designed to measure schizotypal traits, Claridge *et al.* repeated their analysis with the Extraversion, Neuroticism and Lie scales of the EPQ removed; the 4-factor solution was essentially unchanged by this manipulation. Claridge *et al.*'s data are broadly consistent with all other factor analytic studies of schizotypy measures (e.g. Kendler & Hewitt, 1992; Raine *et al.*, 1994; Venables & Bailes, 1994), and any differences in results can be

explained in terms of lower subject numbers or fewer scales in the other studies. Thus, most studies find at least two factors (corresponding to factors 1 and 4 above), and the third and/or fourth factors emerge in larger studies (see Claridge & Beech, 1995; Mason *et al.*, 1997).

The Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE)

Using the results of the above factor analyses, Mason *et al.* (1995) developed a new schizotypy scale for use in the normal population. They chose between 24 and 30 items that correlated highly with each of the four factors identified by Claridge *et al.* (1996) and other studies, and named the four components of the scale after those factors, i.e. 'unusual experiences' (UE), 'cognitive disorganization' (CD), 'impulsive non-conformity'(IN) and 'introvertive anhedonia' (IA). The four components all showed adequate internal consistency (coefficient alpha > 0.77), and a good range of scores was obtained for each component in a normal sample of 508 subjects (Mason *et al.*, 1995). Burch *et al.* (1998) administered the scale to 30 individuals on two separate occasions (3-6 months apart), and found high test-retest reliability in all four components. Evidence to date suggests, therefore, that the O-LIFE is a useful measure of the multi-dimensional schizotypy construct. It is used as the main schizotypy measure in the study described in this thesis, and is shown in Appendix 1.

1.2 SCHIZOTYPY AND MODELS OF PSYCHOSIS

General rationale and approach

Factor analytic studies of symptoms shown by schizophrenic patients reveal factors which are strikingly similar to those found in the schizotypy studies discussed above. Bilder *et al.* (1985) and Liddle (1987) found three factors which Liddle called 'reality distortion' (primarily hallucinations and delusions), 'disorganization' (thought disorder and inappropriate affect or behaviour), and 'psychomotor poverty' (poverty of speech, blunted affect and decreased spontaneous movement). The first two factors correspond to what Crow (1980) called the 'positive symptoms' of schizophrenia, and the third factor corresponds to 'negative symptoms'. The factors are clearly similar to the 'unusual experiences', 'cognitive disorganization' and 'introvertive anhedonia' factors found in schizotypy research. Lindenmayer *et al.* (1994) found two additional factors in their analysis of schizophrenic symptoms. One of these was a 'depression' factor and the other included 'hostility' and 'excitement' and was similar to the 'impulsive non-conformity' factor of schizotypy.

These findings add weight to the argument that there are similarities between schizotypal traits and the features of psychotic illness. There is now a large body of research in which psychological models of psychosis have been investigated using healthy individuals assessed for schizotypy. This paradigm assumes that any cognitive abnormalities associated with illness will be present in highly schizotypal healthy people, but to a lesser extent than in people who are ill. The approach is useful as it

avoids a number of methodological difficulties inherent in psychological studies of schizophrenic patients. These include the possible confounding effects of institutionalization and/or antipsychotic medication on neuropsychological task performance, and the problem of maintaining motivation and task-focus in actively symptomatic patients (see Lencz *et al.*, 1995).

Many early psychological studies of schizophrenic patients compared the task performance of symptomatically heterogeneous groups of individuals with that of controls such as non-psychotic depressed patients. In a similar way a lot of schizotypy research has divided subjects into 'high' and 'low' schizotypes and compared cognitive function between these groups, with little regard to the relation between task performance and particular schizotypal traits. As discussed by C. Frith (1992) and Persons (1986), a better way forward in schizophrenia research may be to develop psychological models of specific symptoms, and to compare groups of patients with only those symptoms with controls (without symptoms). More recent research with patients has adopted this 'symptom approach', and schizotypy studies have similarly begun to more closely examine the relation between cognition and particular schizotypal traits. Clearly the O-LIFE scale, with its broad coverage of the different components of schizotypy, is ideal for this purpose.

Three models of psychosis which have been investigated in the schizotypy literature will now be reviewed. These models have been chosen because they are the three areas in which most work has been done to date, and they illustrate a broad spectrum

of approaches, including a non-symptom based model, a symptom-driven cognitive model, and a cognitive neuropsychological approach.

Sustained attention deficits in psychosis

'Sustained attention' refers to the ability to maintain focus on a stimulus over a period of time, and Nuechterlein & Dawson (1984) noted that, relative to controls, both symptomatic and remitted patients with a schizophrenia diagnosis show deficits in sustained attention on standard tasks such as the Continuous Performance Test (CPT). In this task subjects have to respond in a predesignated way to stimuli presented on a screen over a 5-15 minute period. For example, the subject may have to press a button when they see the letter E, except when it is preceded by the letter X. Nuechterlein and Dawson suggested that sustained attention deficits are a trait marker for schizophrenia and should be apparent in individuals vulnerable to psychosis as well as in those who have already developed a psychotic illness.

This proposal has been investigated in a number of studies using the concept of schizotypy, and there is a a general consensus that highly schizotypal subjects do show poorer sustained attention on the CPT relative to low schizotypes (e.g. Chen *et al.*, 1997; 1998; Lenzenweger *et al.*, 1991). These studies used a variety of schizotypy measures (although none used the O-LIFE), and most found an association between impaired sustained attention and the 'unusual experiences' or 'cognitive disorganization' components of schizotypy (akin to the positive symptoms of schizophrenia). Some studies also found an association with the introvertive and

anhedonic aspects of schizotypy (akin to negative symptoms of schizophrenia). These results are clearly supportive of Nuechterlein & Dawson's (1984) general hypothesis, but the associations with particular schizotypal traits are difficult to interpret because of the absence of a specific model linking sustained attention deficits to particular schizophrenic symptoms.

Selective attention deficits in psychosis

As reviewed by M. Eysenck (1984), a number of studies have suggested that inhibitory processes operate in selective attention to prevent irrelevant information from being attended to. Several theorists have proposed that deficits in this inhibitory mechanism give rise to particular psychotic symptoms, and C. Frith (1979) explained hallucinations, delusions and some forms of thought disorder in this way. Frith noted that all potential meanings of a stimulus (e.g. a word, sound or event) are activated in pre-consciousness, but that through inhibition only one (correct) meaning normally reaches consciousness. He suggested that failure of this inhibitory process could cause incorrect or multiple interpretations of events to reach awareness. Incorrect interpretation of sounds may underlie the experience of auditory hallucinations, and misinterpretation of events may underlie delusions. Awareness of multiple meanings of words could lead to the production of odd or inappropriate speech (i.e. thought disorder) (C. Frith, 1979).

The hypothesis that schizophrenic patients have deficits in cognitive inhibition has been tested in a number of ways, one of the most common being Tipper's (1985)

'negative priming' paradigm. In this, a distractor (X) from a priming display becomes a target (X) on an immediately following display. Normals show a longer reaction time (negative priming) to the target X compared with trials where the target (Y) has not previously been a distractor, and this can be explained in terms of inhibitory processes being associated with X because it was previously ignored as a distractor. If schizophrenic patients with positive symptoms have impaired cognitive inhibition, they should show reduced negative priming and respond faster than non-psychotic controls to targets which have previously been distractors. This prediction was confirmed in a study by Beech *et al.* (1989).

A number of studies have tested the above model using normal individuals assessed for schizotypy. In the first of these, Beech & Claridge (1987) administered the STA questionnaire and a negative priming task to 32 male volunteers. Subjects were classified as 'high' or 'low' schizotypes on the basis of their STA scores, and as predicted there was a significant correlation between increasing schizotypy and reduced negative priming. As discussed earlier, the STA correlates highly with the 'unusual experiences' component of schizotypy (which is analogous to some of the positive symptoms of schizophrenia), so Beech & Claridge's (1987) findings are consistent with the predicted association between positive psychotic symptoms and reduced cognitive inhibition. Other studies have replicated and extended this result, often using broader measures of schizotypy than the STA. For example, Peters *et al.* (1994) administered the Combined Schizotypal Traits Questionnaire (CSTQ) used by Claridge *et al.* (1996) in their factor analytic study discussed earlier. In line with predictions, reduced negative priming was associated with high scores on the 'unusual

experiences' factor of the CSTQ. Steel *et al.* (1996) found the same result using the O-LIFE questionnaire, and their study also showed an association between reduced negative priming and high scores on the 'cognitive disorganization' component of schizotypy. This is consistent with C. Frith's (1979) proposal that some forms of thought disorder reflect impaired inhibitory processes.

In summary, there is good evidence from work with both patients and normal volunteers that some of the positive symptoms of schizophrenia, and their analogous schizotypal traits, are associated with reduced 'cognitive inhibition'. C. Frith's (1979) cognitive model of schizophrenia was one of the first to focus on particular symptoms, and although it is quite successful at explaining a number of psychotic phenomena, Frith (1992) has since rejected it in favour of a new model which he feels to be more detailed and specific. A component of that model will be discussed next, but a full description of the model will be given in section 1.3 of this Introduction.

Impaired executive function in psychosis

Much work with schizophrenic patients has followed the tradition of classical neuropsychology in attempting to infer abnormalities in particular brain regions from patients' performance on standard tests. One of the most intensively studied areas is 'executive function', which describes the process whereby cognitive systems are co-ordinated so that complex tasks can be carried out. It is thought to be required for the planning and execution of complex behaviours, for the generation of strategies and for the inhibition of strategies or behaviours which are inappropriate. Executive

functioning is thought to activate the prefrontal cortex and connected areas in posterior brain regions including the temporal lobe (McCarthy & Warrington, 1990).

As part of his cognitive neuropsychological model of schizophrenia, C. Frith (1992) argued that negative symptoms such as avolition and poverty of speech, and the positive symptoms of inappropriate or stereotyped speech or behaviour, reflect impairments in executive function. Such patients are presumed to have difficulty generating strategies or actions (leading to negative symptoms) or inhibiting ongoing behaviours (leading to positive symptoms). In line with this model, Liddle & Morris (1991) found that a group of schizophrenic patients was impaired relative to standard criteria on a battery of executive function tasks. In particular, Liddle's (1987) 'psychomotor poverty' factor of negative symptoms was associated with difficulty generating words on a word fluency task, whereas the 'disorganization' factor of positive symptoms (including inappropriate affect or thought disorder), was associated with problems inhibiting inappropriate responses on the Stroop task. The factor of 'reality distortion' (hallucinations and delusions) was not related to task performance.

Studies in which schizophrenic patients perform the Wisconsin Card Sorting Test (WCST) also support the model of impaired executive function in schizophrenia. The WCST requires subjects to sort patterned cards along one of several dimensions (e.g. shape, number, colour), and on the basis of feedback to then shift sorting strategy to a new dimension and inhibit the previous response set. As predicted by Frith's (1992) model, patients with schizophrenia usually take longer to work out a sorting strategy

or show more perseverations than controls to a previously correct dimension (see Elliott & Sahakian, 1995). However, the relation between symptoms and WCST performance is less clear, with only some studies (e.g. Rosse *et al.*, 1991) supporting Frith's (1992) prediction of an association between impaired performance and particular negative and positive symptoms.

Negative symptoms are most common in chronic schizophrenic patients who have been ill for a number of years (Crow, 1980), and it is these patients who are most likely to show poor motivation and attention on cognitive tests. One possibility, therefore, is that any association between negative symptoms and poor performance on executive tests may simply reflect patients' distractibility or lack of interest rather than a specific executive deficit. This raises the possibility of testing normal volunteers assessed for schizotypy, as by definition these healthy individuals should not show clinical levels of amotivation. One might expect on the basis of Frith's (1992) symptom-specific predictions, and by analogy with Liddle & Morris's (1991) study with schizophrenic patients, that poor performance on executive tests may be associated with the schizotypal traits of 'introvertive anhedonia' and 'cognitive disorganization', but not with 'unusual experiences'.

Studies testing this precise hypothesis have not yet been done, although several workers have looked more generally at the relation between WCST performance and schizotypy. These have usually found an association between increasing schizotypy and poorer scores on the WCST but, as with studies on schizophrenic patients, the relation with particular schizotypal traits is less clear. For example, Lenzenweger &

Korfine (1994) found that 23 students who scored high on the Chapmans' Perceptual Aberration Scale (PAS) of schizotypy were impaired on the WCST relative to low PAS scorers. Other studies which assessed both positive and negative schizotypal traits have usually found an association between impaired executive function and scores for both sets of traits (e.g. Obiols *et al.*, 1997; Raine *et al.*, 1992). Several different schizotypy scales have been used in these various studies, and it is possible that the findings are still generally compatible with C. Frith's (1992) symptom-specific predictions discussed above. For example, the PAS contains some items relating to 'cognitive disorganization', so Frith might expect scores on the scale to have some association with executive function.

Summary

In this section we have seen how the schizotypy construct can be useful in investigating models of psychosis in normal volunteers without the potential confounding effects of poor motivation and medication found in patient studies. The three models discussed above are all able to explain some of the empirical data, but Frith's (1992) cognitive neuropsychological model (to be discussed next), is perhaps the most ambitious yet in its attempt to account for most of the symptoms of psychosis in terms of impairments in a single cognitive system - the system involved with representation of mental states ('metarepresentation').

1.3 C. FRITH'S (1992) MODEL OF PSYCHOSIS

Introduction

Models of psychosis can generally be classified as either psychological or neuropsychological. The former attempt to explain aetiology or symptomatology purely in terms of psychological processes such as abnormalities in particular cognitive functions. The models discussed earlier of impaired sustained attention (Nuechterlein & Dawson, 1984) or impaired selective attention (C. Frith, 1979), fall within this group. Neuropsychological approaches focus on brain pathology and attempt to infer abnormalities in particular brain regions from patients' performance on standard psychological tests. For example, Shallice *et al.* (1991) administered a large battery of neuropsychological tests to schizophrenic patients and found that all showed particularly poor performance on tests of executive function. As such tests are thought to challenge the frontal lobe, Shallice *et al.* concluded that frontal pathology is implicated in schizophrenia. However, these authors provided no specific model to explain how impaired executive function could lead to particular psychotic symptoms.

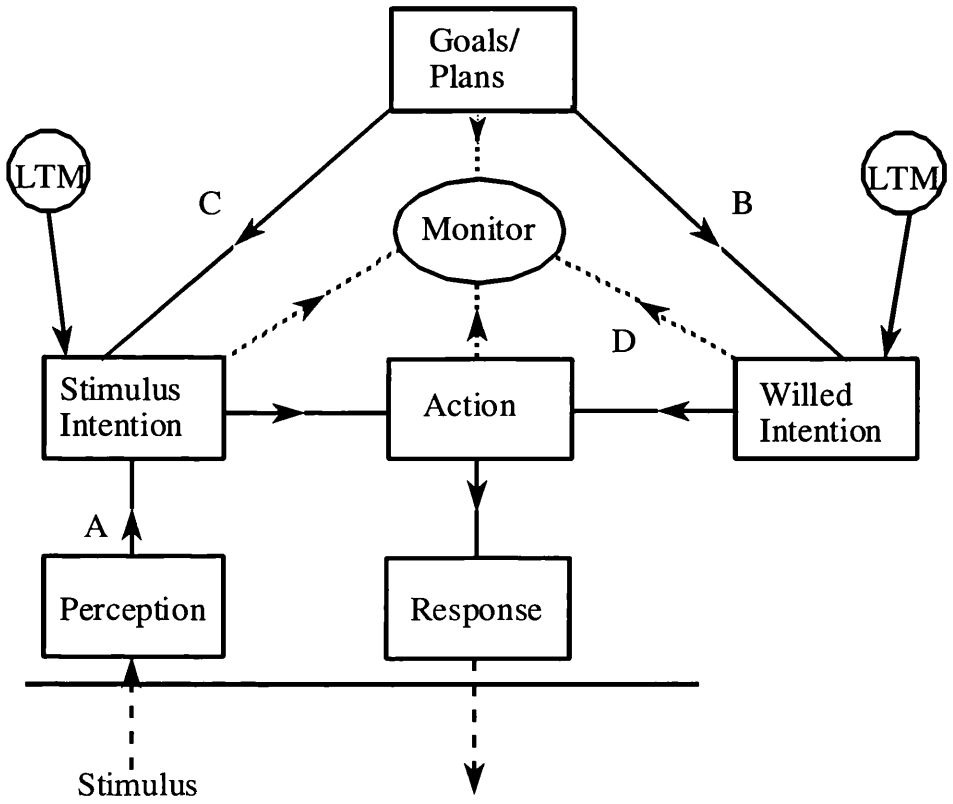
C. Frith (1992) suggested that an important step forward would be the development of a model which focused on both the psychological and physiological levels of explanation, and made links between these two levels. He argued that the psychological level should explain symptoms in terms of abnormal cognitive processes, which could then be linked to brain systems using, for example, brain

imaging techniques. Frith's cognitive neuropsychological model of schizophrenia forms the basis of the present study. The following review of the model focuses on the psychological level of explanation, and the reader is referred to C. Frith (1992) for discussion of possible underlying brain systems. The framework of the model as it first appeared in 1987 will be briefly described, and parallel developments in metarepresentational theory in normal children and autistic people will then be discussed. Finally, C. Frith's (1992) synthesis of the concepts as relevant to schizophrenia will be presented.

Impairments in self-initiated action in schizophrenia

C. Frith (1987) argued that there are normally two routes by which actions occur (see Figure 1.1). They can be a response to an external stimulus (route A) or can be self-initiated (route B). By the first route, a stimulus is perceived and, in consultation with long-term memory (LTM), an intention to act and an action are generated on the basis of the stimulus meaning (e.g. a sign 'PULL' on a door leads to one pulling the door open). By the second route a plan or goal leads, in consultation with LTM, to the generation of a 'willed intention' and action appropriate to that goal (e.g. a goal to get out of an unfamiliar building leads to one searching for a door). If a particular stimulus leads to intentions or actions which conflict with a current goal then these can be inhibited by route C (Figure 1.1).

Fig 1.1 Two routes to action and the monitoring system (adapted from C. Frith, 1992)



We saw in section 1.2 that Frith proposed that impaired executive function underlies some of the negative and positive symptoms of schizophrenia, and it is impairments in precisely the above action system which Frith was implicating here. Thus, a patient who has goals and plans but cannot translate these into willed intentions or actions (an impairment at B in Figure 1.1) may show negative symptoms such as poverty of action, speech and thought, flat affect and social withdrawal. On the other hand, a patient who is unable to inhibit intentions and actions triggered by external stimuli (an impairment at C) may show positive symptoms such as inappropriate or incongruous behaviour, speech or affect. As discussed in Section 1.2, some neuropsychological

studies with schizophrenic patients (e.g. Liddle & Morris, 1991) support this model by showing the predicted relationship between symptomatology and impairments in generativity or inhibition of action.

A useful feature of this model was that it enabled C. Frith (1987) to go on to account for some other positive symptoms of psychosis, namely the 'passivity experiences' such as thought insertion (where the patient believes that thoughts which are not his own are put into his head from outside), delusions of control (where the patient believes his actions are under the control of an external force) and auditory hallucinations ('hearing voices'). On the basis of a number of studies of rapid error correction on motor tasks in normal volunteers, Frith postulated a monitoring system which can distinguish between internally- and externally-generated action, and which oversees current goals and plans, intentions and actions. He suggested that passivity symptoms arise due to an impairment in the monitoring of willed intentions (via route D on Figure 1.1), so that thoughts, actions or subvocal speech (generated via an intact route B) are not recognised as internally-generated, and are consequently perceived as inserted thoughts, controlled actions and external 'voices' respectively.

This component of Frith's model has been investigated in a number of computer-based and video-game tasks in which rapid error correction was required, the argument being that patients with an impaired internal monitor would need to rely on external (perceptual) feedback of their actions, so would perform poorly on versions of the task where external feedback was not available. Results have been largely supportive of the model and C. Frith & Done (1989), for example, found that (as

predicted) poor performance of schizophrenic patients on this type of task was specifically related to symptom ratings of delusions of control and thought insertion.

Developments in metarepresentational theory

At the same time as the above model was being developed, a number of research groups were theorising about awareness of mental states (such as goals, intentions, knowledge, beliefs) in self and others. This work will be described here briefly and then linked to Frith's model of psychosis in the following section.

Premack & Woodruff (1978) coined the term 'theory of mind' (ToM) for the cognitive ability to represent the mental states of oneself or others in order to understand or predict behaviour. They observed apparently deceptive behaviour within groups of chimpanzees and suggested that, at some level, these animals could infer that others had knowledge and beliefs which could be manipulated in order to produce a desired behaviour. It is still an empirical question as to whether chimpanzees and other apes do have this ability, and if so to what level it has evolved (van Hooff, 1994).

The concept of ToM has been adopted widely within human cognitive psychology as it accounts well for many of the complex social behaviours of normal humans such as lying, bluffing, joking and irony. These behaviours are all similar in that they have a 'surface' form which is different from the underlying meaning, and this meaning can only be understood by inferring internal mental states. Thus, someone who pulls a

long face while saying of a lecturer, "He was exciting" is interpreted as being ironic because we infer that, contrary to the surface meaning of their statement, they think the lecture was boring.

Wimmer & Perner (1983) argued that a defining feature of ToM is the ability to infer a false belief, as this requires attribution of a mental state which runs counter to the 'surface' evidence. They devised the 'Sally-Ann' false belief task to test ToM in normal children. This consists of a story in which Sally puts a marble in a box and leaves the room. Ann then moves the marble into a basket. Sally returns, and the child has to predict where Sally will look for the marble. Wimmer and Perner argued that a child could only answer correctly (by saying "in the box", and not in the basket where it actually is) by attributing Sally's false belief, i.e. by having a theory of mind. The task is said to tap first-order ToM as it requires attributions such as "She thinks that....", and a lot of research (reviewed by Astington & Gopnik, 1991) has shown that normal children only pass the task when they reach the age of about 4 years. Second-order tasks requiring attributions such as "She thinks that she thinks that . . ." tend to be passed around the age of 7 years. Cognitive theorists such as Leslie (1987) used these data to argue that a 'theory of mind mechanism' dedicated to the representation of mental states ('metarepresentation') develops gradually through normal childhood.

Leslie (1987) made the important point that, by definition, children's pretend play involves objects being used in a different way to that suggested by their 'surface' form. For example, a child may hold a banana to its mouth and speak into it as though

it were a telephone. Leslie proposed, therefore, that the emergence of pretense in normal children around the age of 18 months may be one of the first signs of a child's developing metarepresentational ability. Leslie further noted that a marked absence of pretend play is one of the three behavioural features of the autistic syndrome, the other two features being impaired socialization (e.g. behaving in a withdrawn, aloof or odd way) and impaired communication (e.g. lack of speech or facial expression or inappropriately verbose language) (Wing & Gould, 1979). Leslie (1987) suggested that the absence of pretense in childhood autism may mean that people with this disorder lack the ability to represent mental states.

Leslie's theorising provoked a large body of work in which theory of mind tests of varying complexity were given to autistic people and control subjects (see Baron-Cohen *et al.*, 2000, for a review). The first study (Baron-Cohen *et al.*, 1985) found that only 20% of a sample of autistic people passed the Sally-Ann false belief task, whereas more than 85% of Down's syndrome children and normal 4-year old children (matched on mental age with the autistic group) passed the task. Baron-Cohen (1989) went on to show that all of the autistic 'passers' in his first study failed a second-order test of ToM, whereas mental age-matched controls performed significantly better. A number of studies (e.g. Leslie & Thaiss, 1992) have also demonstrated that autistic people score badly on ToM tasks but perform well on equally difficult control tasks which do not require metarepresentation, and together these studies are strongly supportive of the hypothesis of impaired ToM in autism. U. Frith (1989) pointed out that, in addition to explaining the absence of pretend play in autism, this hypothesis can account for the features of impaired socialization and communication in the

disorder. Thus, an autistic person who fails to understand that other people have internal mental states may not see any purpose in socialising, or may fail to understand the intention to communicate signalled by non-verbal cues such as a smile. As a result, the person may withdraw socially or remain mute. Similarly, a failure to attribute what a listener expects in a conversation may lead to socially 'odd' utterances or the production of verbose or pedantic speech, pitched at a level inappropriate to the listener's knowledge (U. Frith, 1989).

Other psychological models of autism

The model of impaired ToM in autism has been very influential and widely researched, but it should be acknowledged at this point that other psychological theories have also been advanced to explain either the the performance of autistic people on theory of mind tests and/or the behavioural features of autism. Currie (1996) and Harris (1995) accept that autistic people have difficulty representing mental states but suggest that this reflects a more fundamental problem with imagining any abstract or hypothetical state of affairs. A number of studies have found an association between impaired ToM and poor performance on tests of planning (e.g. Ozonoff & McEvoy, 1994), and this evidence has been cited by Currie and Harris in support of their hypothesis.

Russell and colleagues (e.g. Russell, 1998) proposed that autistic subjects perform poorly on false belief tasks because they are 'captured' by the salient irrelevant information present in many tests of ToM (e.g. the current rather than previous location of the marble in the Sally-Ann task), and fail to inhibit this information when

responding. They cited a number of studies (e.g. Hughes & Russell, 1993) which found that autistic people have problems in disengaging from salient detail, and that this difficulty was related to impaired performance on false belief tasks. If the primary psychological impairment in autism is disengagement rather than representation of mental states, one might expect autistic people to perform poorly on any task in which salient information must be inhibited. However, as discussed earlier, Leslie & Thaiss (1992) and other workers gave ToM and equally difficult control tasks to autistic people, and found only an impairment on the ToM tasks. As the control tasks in these studies usually required disengagement from salient detail, these results do not support Russell's hypothesis.

Finally, the 'weak central coherence' (WCC) model (U. Frith, 1989) attempts to explain some features of autism not accounted for by the impaired ToM hypothesis. Unlike the Harris (1995) and Russell (1998) models discussed above, therefore, the WCC account is not seen as a competitor to the ToM hypothesis, but rather a parallel theory which focuses on non-social features of autism. The model notes that autistic people tend to focus on detail rather than gestalt, and suggests that (unlike normal humans) they fail to give priority to understanding meaning. Empirical evidence for this has been found on the embedded figures test, where autistic people are particularly good at finding objects hidden within meaningful pictures (e.g. Shah & U. Frith, 1983). Similarly, autistic people perform poorly on tasks which require the use of sentence context to disambiguate word meanings (e.g. U. Frith & Snowling, 1983). The weak central coherence model will be discussed in more detail in Section 1.4 of

this Introduction, as it forms the basis of the second part of the study presented in this thesis.

C. Frith's (1992) metarepresentational account of psychosis

C. Frith & U. Frith (1991) noted that there is a striking similarity between the behavioural features of autism and some of the negative and positive symptoms of schizophrenia. Thus, both autistic and schizophrenic people can show social withdrawal, flat affect, poverty of speech, inappropriate or odd behaviour and speech, and stereotyped and perseverative behaviour. We saw earlier that in schizophrenia these features can be explained in terms of impairments in the willed action system, with the patient having difficulty generating or inhibiting actions. However, we have also seen that in autism most of the same features have been explained in terms of impaired representation of other people's mental states. In linking these two areas of research, Frith & Frith (1991) made the important suggestion that the generation of willed action and the inhibition of inappropriate action depend upon representation of one's own goals and plans (i.e. theory of mind, ToM). Thus, for a goal or plan to be translated into a willed intention, or for the goal or plan to be used to inhibit a stimulus intention, one must be aware of what one wants to do. Similarly, 'monitoring' of willed intentions leading to actions involves awareness of those intentions. By this account, those negative and positive symptoms of schizophrenia which involve impairments in generativity or inhibition (what C. Frith later called the 'behavioural signs') may reflect impaired representation of own goals and intentions. Similarly, the passivity symptoms such as delusions of control and thought insertion

reflect intact representation of own goals (because an action is generated), but impaired representation of one's own intention underlying that action.

In making these links, Frith & Frith (1991) were proposing that the features of both autism and schizophrenia reflect impairments in metarepresentation. Almost all investigations of ToM in autism have given tasks requiring representation of other people's mental states, so it is perhaps not surprising that theoretical accounts of autistic features focused on problems understanding others' minds. Frith & Frith's (1991) model suggests, however, that autistic features such as social withdrawal, poverty of speech and inappropriate or odd behaviour, could equally well be explained in terms of impaired awareness of own mental states. These authors proposed, therefore, that the whole metarepresentational system (i.e. awareness of others and self) is impaired in autism. This hypothesis is useful as it enables us to explain autistic features such as stereotyped and perseverative behaviour, which are difficult to account for if we assume only impaired understanding of others' minds in autism.

By analogy with the above arguments, Frith & Frith (1991) suggested that, in addition to problems representing their own mental states, schizophrenic patients may have difficulties understanding others' minds. Thus, 'behavioural signs' such as poverty of speech and action, and inappropriate or odd speech and action, could reflect problems attributing other people's mental states in the same way as postulated for autism. Like autism, therefore, Frith and Frith hypothesised that schizophrenic patients with these symptoms have deficits in the whole meta-representational system, with impaired representation of both own and others' mental states.

Frith & Frith (1991) made the important point that autism is a condition usually diagnosed in early childhood, whereas psychotic illnesses typically begin in the second or third decade of life with an acute episode. They proposed that autism may involve impaired development of the metarepresentational system, so that autistic people never fully understand theory of mind. In contrast, Frith and Frith suggested that psychotic people may have had a normally developed metarepresentational ability which started to malfunction at the onset of illness. This enables us to explain positive psychotic symptoms such as delusions of persecution and reference in terms of incorrect attribution of the mental states of other people. Thus, a patient who knows (from earlier normal experiences) that people have intentions and beliefs may continue to infer them but may do so wrongly, assuming, for example, that a stranger in the street intends to harm them or is thinking about them. This part of the model suggests that paranoid delusions about other people reflect a less severe meta-representational impairment than the positive and negative 'behavioural signs', as in the former patients still infer mental states (albeit incorrectly), whereas the latter reflect a severe loss of the patient's earlier ToM ability (C. Frith, 1992). Finally, as Frith's model explicitly links symptomatology with metarepresentational impairment, it predicts that remitted schizophrenic patients (i.e. those with no current symptoms) should have intact theory of mind. The complete model is summarised in Table 1.1.

Table 1.1 Theory of mind ability as related to psychotic symptoms in Frith's model

Group	Symptoms	Representation of own goals	Representation of own intentions	Representation of others' mental states
1	Behavioural signs	X	X	X
2	Paranoid symptoms	✔	✔	X (ToM still present, but errors occur)
3	Passivity symptoms	✔	X	✔
4	No symptoms	✔	✔	✔

Representation of other people's mental states by psychotic patients

A number of studies have explored Frith's predictions about the ability of schizophrenic patients to represent others' mental states, and the findings have been generally supportive of the model. Psychotic patients typically have a range of symptoms from groups 1 to 3 in Table 1.1, and several researchers have used a correlational approach to examine the relation between symptom ratings and ToM ability. For example, Sarfati and colleagues (Sarfati *et al.*, 1997a, b; 1999; Sarfati & Hardy-Baylé, 1999) found that schizophrenic people were poorer than controls at choosing the most suitable card to complete comic strip stories which required the understanding of characters' intentions, desires or false beliefs. Examination of

symptom scores showed that task performance was particularly poor for patients with high ratings for 'thought and speech disorganization' (i.e. positive 'behavioural signs' in C. Frith's terminology). Langdon *et al.* (1997) similarly found subgroups of their schizophrenic sample to be impaired relative to controls on a picture-sequencing task requiring attribution of mental states to story characters. Poor performance was associated with high ratings for negative behavioural signs but, contrary to C. Frith's model, there was no evidence that paranoid symptoms were associated with impaired ToM.

Mitchley *et al.* (1998) investigated schizophrenic people's understanding of irony, as this skill is thought to require attribution of a speaker's intentions. Results showed that patients with high scores for negative behavioural signs were impaired on the irony task compared to psychiatric controls; again, however, there was no association between task performance and paranoid symptomatology. Finally, Drury *et al.* (1998) and Doody *et al.* (1998) tested schizophrenic patients and psychiatric controls on second-order false belief tasks and again found that high scores for behavioural signs were associated with poor task performance. In line with Frith's model, Drury *et al.* found that task deficits disappeared when symptoms remitted.

In summary, all of the above studies provide partial support for Frith's model, suggesting that impaired representation of other people's mental states is clearly associated with the behavioural signs of schizophenia, but showing little evidence of an association with paranoid symptoms. Interestingly, a number of studies carried out by Frith's research group analysed the data rather differently from the above studies

and found that both behavioural signs and (to a lesser extent) paranoid symptoms were associated with impaired ToM. The tasks given in these studies required understanding of hints in everyday conversation (Corcoran *et al.*, 1995), conversational maxims (Corcoran & C. Frith, 1996), false belief and deception (C. Frith & Corcoran, 1996) and jokes (Corcoran *et al.*, 1997), and in all cases the data were analysed using symptom subgroups rather than the correlational approach used in other studies. The symptom subgroups were formed hierarchically in accord with Frith's predictions about ToM ability (see Table 1.1), so that any patients with behavioural signs fell into Group 1 irrespective of their other symptomatology, because behavioural signs are thought to reflect severely impaired ToM. Similarly, Group 2 comprised patients who had paranoid symptoms and no behavioural signs, as these people were expected to be better than those in Group 1 at representing the mental states of others, but to still make errors. Group 3 consisted of patients with only passivity symptoms, as these should have an intact ability to infer others' mental states, and Group 4 comprised symptom-free patients who should also score normally on the tasks.

As already noted, these studies by Frith's group found that, as predicted, impaired ToM was associated with behavioural signs and (to a lesser extent) paranoid symptoms. In addition, patients with only passivity symptoms, or with no symptoms, had an intact ability to represent others' mental states. Regarding the effect of paranoid symptoms, the difference between these findings and those of other studies may reflect the different ways in which data were analysed. For example, in correlational analyses, the strong association between behavioural signs and impaired

ToM may mask the smaller contribution of paranoid symptomatology. It may be that any effect of paranoid symptoms is only revealed when a paranoid subgroup without behavioural signs is compared with controls (as in the studies by Frith's group). Pickup & C. Frith (in press) investigated this hypothesis by using both correlational and subgroup analyses to investigate the relation between symptoms and ToM task performance in schizophrenic patients. As predicted, both analyses showed an association between impaired ToM and the presence of behavioural signs, but only the latter analysis revealed an association with paranoid symptomatology.

Schizotypy and representation of other people's mental states

In the study to be described in this thesis, C. Frith's (1992) hypotheses about the ability of psychotic patients to represent the mental states of other people will be investigated using the schizotypy paradigm discussed in Sections 1.1 and 1.2 of this Introduction. This model assumes a continuum of psychosis-proneness, so that normal individuals who score high for schizotypy are predicted to show similar (but less marked) cognitive abnormalities to schizophrenic patients. This approach has the advantage of allowing a large sample to be relatively easily collected, whereas work with schizophrenic patients is typically very time consuming. In addition, a study with normal volunteers will avoid the potentially confounding factors of illness severity and chronicity, institutionalization and poor attention, memory or motivation inherent in patient studies. This is particularly important as Frith's model predicts that the poorest performance on ToM tasks is shown by schizophrenic patients with behavioural signs. These patients are typically those with the most chronic, severe forms of illness, and

several commentators have suggested that their poor performance on ToM tasks in the studies discussed earlier may simply reflect non-specific effects of illness severity or chronicity.

Pickup & C. Frith (in press) addressed this issue by giving schizophrenic patients ToM tasks and equally difficult control tasks which did not require attribution of mental states. They found that patients were differentially impaired on the ToM tasks, and argued for a specific ToM deficit in schizophrenia over and above the non-specific effects of illness. If it is found in the present study that poorer performance on ToM tasks in normal individuals is associated with the presence of particular schizotypal traits, we shall have further evidence that ToM deficits in psychotic patients are directly related to symptoms. It is important to note that, in the present study, any ToM impairments in normal subjects are expected to be small relative to those found in actively symptomatic patients. As we have already seen, C. Frith's (1992) model postulates intact ToM in remitted (symptom-free) schizophrenic patients. It is likely, therefore, that any variation over the normal population is subtle and related to speed of 'on-line' processing and/or the accurate application of ToM in real-life situations.

To date, one research group (Langdon & Coltheart, 1999) has explored ToM and schizotypy in normal volunteers. The study comprised two separate parts in which a total of sixty-eight participants were given a picture-sequencing task requiring cards to be placed in the correct order to tell a meaningful story. Some of the stories ('social-script') involved people acting out everyday social routines, others

('mechanical') involved people and objects interacting causally, and others ('false belief') involved people being unaware of an event and acting on a false belief. The latter condition tested participants' ToM ability. In both parts of their study, Langdon and Coltheart found that high total scores for schizotypy were associated with poorer performance in the false belief condition of the task, but were unrelated to performance in the other conditions (in accord with Frith's model). However, in Experiment 1 poor scorers were more likely to report schizotypal traits analogous to the negative symptoms of schizophrenia, whereas in Experiment 2 of the study (where the sample size was only 28), poorer ToM scores were associated with positive symptom traits. Langdon and Coltheart suggested several post hoc explanations for this inconsistency, one of which pointed to the restricted range of scores for negative schizotypal traits of the participants in Experiment 2.

Both parts of Langdon & Coltheart's (1999) study used the picture-sequencing task, but in Experiment 2 two additional tasks were introduced as control measures. The first of these was an extra picture-sequencing condition ('capture'), in which the depicted story included a salient, but misleading, piece of information, which if focused upon led to the pictures being sequenced incorrectly. This was a control for Russell's (1998) explanation of poor ToM task performance in terms of capture by salient, but inappropriate, information. The second control task used by Langdon and Coltheart was the Tower of London planning task, in which participants must mentally plan a sequence of moves in order to transfer coloured balls from one position to another in a particular order. This was a control for Harris (1995) and Currie's (1996) explanation of poor ToM task performance in terms of problems

imagining abstract or hypothetical states of affairs. Langdon & Coltheart (1999) did not find any association between schizotypy scores and subjects' performance on these two control tasks, and concluded that their results provided strong evidence that high schizotypy is related to difficulties in the representation of mental states in accord with C. Frith's (1992) model.

The present study: Schizotypy and ToM

In the study described in this thesis, it is hoped to extend and clarify Langdon and Coltheart's (1999) work. A screening questionnaire (the STA; Claridge & Broks, 1984) will be used to select roughly equal numbers of participants with low, average and high schizotypy to ensure a broad range within the sample. This should avoid Langdon & Coltheart's (1999; Experiment 2) difficulty with a restricted range of schizotypy scores. Schizotypal traits will then be assessed using the O-LIFE questionnaire (Mason *et al.*, 1995) which, as we saw earlier, asks about 'unusual experiences' (analogous to the paranoid and passivity experiences of psychosis), 'cognitive disorganization' and 'impulsive non-conformity' (analogous to positive behavioural signs in C. Frith's terminology) and 'introvertive anhedonia' (analogous to negative behavioural signs). Langdon and Coltheart used the Schizotypal Personality Questionnaire (SPQ; Raine, 1991), which has relatively few questions about negative schizotypal traits. In contrast, the O-LIFE asks similar numbers of questions about each domain of schizotypy, so should assess each one equally well.

Participants' ability to represent the mental states of others will be assessed in the present study using a story test developed for normal adults by Fletcher *et al.* (1995) and used with young and elderly normal adults by Happé *et al.* (1998). Subjects are asked to read to themselves 8 short passages which require attribution of mental states to story characters in real life situations. At the end of each passage they answer a question which tests ToM ability, and the scores on these questions, together with time taken to read the passages, are used as measures of ToM. It is hoped that assessment of the accuracy and speed of participants' 'on-line' processing about real-life situations, will enable subtle variations in ToM over the normal population to be detected.

By analogy with Langdon & Coltheart's (1999) work, two control tasks will be given in the present study. First, subjects will read and answer questions on 8 'physical' stories, which require reasoning about everyday situations without mental state attribution. Fletcher *et al.* (1995) developed these stories and found that they were matched in difficulty with the ToM stories, and it is intended that this task will control for the possibility that poor performance on ToM stories reflects a general problem with imagining abstract or hypothetical states of affairs (Currie, 1996; Harris, 1995). The second control task to be used here is the Cognitive Estimates Test (Shallice & Evans, 1978) which requires participants to make a 'best guess' in response to questions such as 'How fast do race horses gallop?' and 'How many camels are there in Holland?'. In generating accurate responses subjects often need to inhibit their initial or 'impulsive' guess in order to produce a reasoned estimate, so it is intended that this task will control for the possibility that poor performance on ToM stories

reflects 'capture' by salient information and difficulties with inhibition (e.g. Russell, 1998).

It should be noted that both the 'physical' stories and Cognitive Estimates tests are measures of executive function as they assess abstract reasoning. As we saw in Section 1.2, a number of studies have found an association between high schizotypy and poor scores on executive tests such as the Wisconsin Card Sorting Test (e.g. Lenzenweger & Korfine, 1994), so we may expect in the present study that high schizotypy will predict poor performance on the 'physical' stories and Cognitive Estimates tests. This does not rule out the use of these tests as a control for the ToM stories, as the outcome of interest will be the presence (or not) of a statistical interaction between schizotypy and scores on the ToM and control tests. If high schizotypy is associated with impaired ToM over and above any executive dysfunction , then this interaction will be statistically significant.

In the present study each participant will also complete a short verbal IQ test, so that IQ differences can be co-varied in the analysis. This is an improvement on Langdon & Coltheart's (1999) study where the IQs of participants were not assessed. The relationship between schizotypal traits and ToM will be examined in the present study using both correlational and subgroup analyses. Following Langdon & Coltheart (1999), it is predicted that participants with a high total schizotypy score will perform worse on ToM tasks than those with a low score. Furthermore, on the basis of C. Frith's (1992) model of schizophrenia, and by analogy with Pickup & C. Frith's (in press) study with schizophrenic patients, it is predicted that correlational and

subgroup analyses will reveal associations between poorer ToM performance and higher scores on the cognitive disorganization, impulsive non-conformity and introvertive anhedonia subscales of the O-LIFE (as these are analogous to the 'behavioural signs' of schizophrenia). Following Pickup & C. Frith (in press), subgroup analyses may additionally show an association between lower scores on ToM tasks and higher scores for the unusual experiences component of schizotypy (analogous to the positive symptoms of schizophrenia).

1.4 'WEAK CENTRAL COHERENCE' AND SCHIZOTYPY

Introduction

To introduce a final feature of the present study, another psychological model of autism (mentioned already in Section 1.3) will be considered. This is not a competitor to the ToM hypothesis, but is seen as a useful additional model that can account for some of the non-social features of autism which the theory of mind model does not explain. A large body of research with autistic people suggests that they tend to focus on detail rather than gestalt, and U. Frith (1989, p. 101) suggested that a cognitive style specific to autism is failure of the "normal operation of central coherence [which] compels us human beings to give priority to understanding meaning." In the first part of this section, the empirical evidence for 'weak central coherence' (WCC) in autism will be reviewed. Studies will then be discussed which show that schizophrenic patients may also show weak central coherence. Finally, the rationale

will be presented for the final part of the present study, in which the relation between central coherence and schizotypy is investigated.

The case of autism

In his early observations of autistic people, Kanner (1943, reprinted in Kanner, 1973) suggested that a central feature of the disorder was "the inability to experience wholes without full attention to the constituent parts" (p. 38). As discussed by Bailey *et al.* (1996), the ease with which autistic children detect changes in detail may have some bearing on their resistance to change and the "markedly restricted repertoire of activity and interests" used as a diagnostic feature in DSM-IV (APA, 1994; p. 66). A focus on detail may also have some bearing on the relatively high incidence in autism of 'islets of ability' (e.g. good rote memory), or in-depth knowledge of unusual topics. In addition, it may be relevant to the 'idiot savant' phenomenon wherein a small proportion of (usually autistic) people develop an isolated talent in areas such as music or mathematics, to a level higher than that found in normals (see Bailey *et al.*, 1996; Happé & U. Frith, 1996).

A large body of research in experimental psychology has confirmed Kanner's clinical impressions, showing that autistic people pay more attention to parts than wholes and fail to extract the global meaning from stimuli (see U. Frith & Happé, 1994, for a review). For example, Hermelin & O'Connor (1967) found that children with autism performed similarly on tasks requiring immediate recall of meaningful sentences or random word strings. In contrast, mentally handicapped controls scored significantly

better in the sentence condition, which suggests that meaning influenced their performance. Similarly, Tager-Flusberg (1991) found that normal and learning disabled controls showed significantly better recall of semantically-related nouns than unrelated nouns, whereas the performance of verbal MA-matched autistic children was little affected by word meaning.

U. Frith & Snowling (1983) devised a task in which subjects had to read aloud sentences containing words with two possible pronunciations (i.e. homographs such as 'tear'). The sentences were constructed so that context determined the correct pronunciation of each homograph. Thus, the way subjects pronounced the words gave a measure of their understanding of meaning. U. Frith and Snowling found that autistic subjects were specifically impaired, relative to dyslexic or normal controls matched on reading age, at giving the correct word pronunciation in context, a result compatible with the weak central coherence account of autism. Happé (1997) extended these results, using conditions in which the homograph came either before or after the sentence context. As predicted, young normal controls showed an effect of context position, pronouncing more of the homographs correctly when they appeared after the context than when they appeared before it. In contrast, autistic individuals were relatively insensitive to context position. These results were replicated by Jolliffe & Baron-Cohen (1999) with a sample of adults diagnosed with autism or Asperger syndrome.

As discussed by U. Frith (1989), autistic people show a characteristic 'spiky' performance profile on subtests of the Wechsler intelligence scales (e.g. WAIS-R;

Wechsler, 1981), and this may also be partly explained in terms of weak central coherence in the disorder. For example, peak autistic performance is usually found on the Block Design subtest, in which subjects must use patterned blocks to construct (as quickly as possible) a specific gestalt pattern provided for them on a card. U. Frith (1989) suggested that the good performance of autistic people on this task may reflect the relative ease with which they can 'mentally segment' the provided gestalt into its constituent parts. This hypothesis was confirmed by Shah & U. Frith (1993) who found that autistic individuals performed better than normal and mildly retarded controls in a standard condition in which the to-be-copied gestalt was presented whole. In contrast, when the to-be-copied design was pre-segmented, all groups performed similarly, reflecting the fact that controls showed a greater improvement than autistic people in that condition.

Another paradigm in this area of research has involved the administration of visual illusions to autistic and control subjects, the hypothesis being that if autistic individuals are less influenced by context, they should be less susceptible than controls to stimuli in which the illusory effect depends upon the integration of 'inducing' contextual cues. Happé (1996) presented six well-known illusions (the Müller-Lyer, Hering, Kanisza triangle, Poggendorff, Ponzo and Titchener circles illusions) to autistic subjects and non-autistic control groups of young normals and children with moderate learning difficulties. Perception of the illusions was tested by asking participants to make size judgements about relevant parts of the stimuli. As a control for general spatial ability, subjects were asked to judge the size of the same parts of the stimuli when no inducing contextual features were present. As predicted, Happé

found that autistic individuals were less susceptible to the illusions and made more accurate size judgements than controls when the inducing context was present. One exception to this was the Müller-Lyer figure, to which both the autistic and control subjects succumbed. Happé suggested that this may be because Müller-Lyer stimuli cannot easily be split into an 'induced' figure and 'inducing' context, as the arrow heads are connected to the to-be-judged lines so form part of the same 'object'.

Finally, Shah & U. Frith (1983) investigated the performance of autistic individuals on the Children's Embedded Figures Test (CEFT; Witkin *et al.*, 1971) which requires the subject to find a 'tent' or 'house' shape (shown by a cardboard cutout) hidden within each of 25 meaningful pictures. Shah and Frith found that autistic children performed significantly better on this task than MA-matched normal or mentally retarded children, showing greater accuracy of performance and a tendency to spot the hidden figure faster than the other groups. Shah and Frith suggested that autistic children performed well on this task "because the overall meaning of the complex figure . . . was not very relevant or dominant for them" (1983, p. 618). Clearly this is consistent with the hypothesis of weak central coherence in autism. Jolliffe & Baron-Cohen (1997) replicated and extended this finding with adults diagnosed with autism or Asperger syndrome, showing that clinical subjects were significantly faster than normal adult controls at finding the hidden shapes in Witkin *et al.*'s (1971) adult Embedded Figures Test (EFT). Interestingly, the accuracy scores (i.e. number of hidden shapes correctly found) did not differ between groups in this study.

A number of studies have administered tests of both central coherence and theory of mind to autistic individuals, and a common finding has been that all autistic subjects show weak central coherence whereas only most show impaired ToM. For example, Happé (1994a) found that all of her autistic subjects performed well on the Block Design subtest of the WAIS-R relative to controls. In contrast, while many of the sample failed standard first-order ToM tasks, a subgroup scored well on these tasks. Similarly, in the homographs study discussed earlier, Happé (1997) found that insensitivity to context was a feature of all of her autistic sample, whereas a subgroup was able to pass standard first-order ToM tasks. No relationship was found between scores on the tests of ToM and weak central coherence in these studies. The results led U. Frith & Happé (1994) to suggest that, while ToM deficits in autism involve impaired metarepresentation and underlie autistic deficits in socialization, communication and pretense, 'weak central coherence' is independent of ToM and more akin to a cognitive style (with autistic people at one end of a normal continuum), which can account for 'non-social' features of autism such as the focus on detail at the expense of gestalt. Autistic 'passers' of ToM tasks are presumed to have some (rudimentary) metarepresentational ability (or to use problem-solving skills to work out a solution: U. Frith *et al.*, 1991), whereas all autistic people are presumed to show weak central coherence.

The case of schizophrenia

We saw earlier that C. Frith and U. Frith (1991) noted striking similarities between some features of autism and schizophrenia. In light of this and the above discussion of

weak central coherence (WCC) in autism, it is noteworthy that some clinical descriptions of schizophrenia also mention a focus on detail rather than gestalt. For example, in proposing problems in schizophrenia with "the maintenance of a major set", Shakow (1950) suggested that schizophrenic patients "could not see the wood for the trees [and examined] each tree with meticulous care". As discussed by Cutting (1985), distortions of perception are common in the early stages of a schizophrenic illness, and in an interview study of recently diagnosed schizophrenic patients, Chapman (1966, p. 229) reported one patient who said, "Everything I see is split up. It's like a photograph that's torn in bits and put together again". Similarly, another of Chapman's patients reported that, "I have to put things together in my head. If I look at my watch I see the watch, watchstrap, face, hands and so on, then I have got to put them together to get it into one piece" (p. 229). Visual hallucinations are relatively rare in schizophrenia (Cutting, 1985), but it is possible that these also sometimes reflect a relative focus on detail rather than gestalt. Thus, Cutting reported that schizophrenic visual hallucinations usually involve changes in only one aspect of the environment, and as an example, he discussed a patient who perceived a huge eye in an otherwise normal face; such experiences are generally found to co-occur with delusions (Cutting, 1985).

Pickup (1997) was the first researcher to suggest that, like autistic people, symptomatic schizophrenic patients may show a cognitive style of weak central coherence. The following section is based on his review of studies in which schizophrenic subjects were given the types of task on which autistic people demonstrate WCC. All of these studies were designed to test hypotheses based on

other psychological models of schizophrenia, but Pickup (1997) concluded that they provide some empirical evidence for weak central coherence in the disorder.

By analogy with the homograph reading studies with autistic individuals discussed earlier (U. Frith & Snowling, 1983; Happé, 1997; Jolliffe & Baron-Cohen, 1999), Naficy & Willerman (1980) gave schizophrenic patients sentences containing an underlined word which had both a common and uncommon meaning, and asked them to choose the context-appropriate meaning from a list provided. Results showed that patients (especially those with symptoms which C. Frith would call 'behavioural signs') were more likely than normal controls to choose the common word meaning when the unusual meaning was required. Naficy and Willerman explained their result within a different cognitive model of schizophrenia, but their data support the hypothesis of weak central coherence in schizophrenia, as the patients seemed to have difficulty using sentence context to determine word meaning. In a similar study, Done & C. Frith (1984) presented schizophrenic patients with sentences from which the final word had been deleted (e.g. "Coming in he took off his . . ."), and in one part of the task participants had to guess a suitable word appropriate to the sentence context. Done and Frith found that schizophrenic individuals (especially those with negative symptoms) had a tendency to give inappropriate responses, a result consistent with a failure to use context to derive meaning.

It was shown earlier that autistic people typically perform well on the Block Design subtest of the Wechsler intelligence scales, and Shah & U. Frith (1993) provided strong evidence that this performance peak reflects weak central coherence. One

problem with the investigation of schizophrenic patients' performance on Block Design is that, as well as involving 'mental segmentation' of a gestalt, the task requires mental rotation and the manipulation of oblique lines, tasks which schizophrenic patients seem to find difficult (see Shapiro, 1952). In addition, Block Design is a demanding task which requires good motivation and attention, factors which may be compromised in severely ill patients. With these issues in mind it is of note, therefore, that several studies have found the scores of schizophrenic patients on the Wechsler scales to show a relative peak on the Block Design subtest. For example, Robertson & Taylor (1985) found that although their sample of 61 schizophrenic males scored significantly more poorly than 41 normal controls on most subtests of the WAIS, schizophrenic performance was as good as that of controls on the Block Design, Vocabulary and Similarities subtests. When patients were divided into symptom subgroups, the most clear evidence of a relative Block Design peak was found in the 'deluded' group (patients with delusions or hallucinations but no negative symptoms). In line with the above discussion these may be people whose relative advantage in 'mental segmentation' was not offset by the poor motivation or attention often associated with the presence of negative symptoms. In a similar study, Green & Walker (1985) found that on a large neuropsychological battery, schizophrenic patients scored significantly worse than controls on all tasks except Block Design and a test of motor control. Within the context of the autism research discussed earlier, these data provide further (limited) support for the hypothesis of weak central coherence in schizophrenia.

By analogy with the work of Happé (1996) with autistic people, several studies have explored the susceptibility of schizophrenic patients to visual illusions. Much of the research has used the Müller-Lyer illusion, a figure which cannot easily be split into 'induced' and 'inducing' parts, and which may therefore be of little use in the investigation of weak central coherence effects (Happé, 1996). As discussed earlier, Happé found that despite being less susceptible to a number of other illusions, autistic people were as likely as controls to succumb to a Müller-Lyer figure. In part of Happé's study where a '3-D' version of the figure was presented, more autistic subjects than controls succumbed to the illusion. Studies in the schizophrenia literature report similar effects with the Müller-Lyer figure, showing that patients are as likely, or more likely, than controls to succumb to the illusion (Capozzoli & Marsh, 1994; Orme *et al.*, 1968; Weckowicz & Witney, 1960).

Such findings make it theoretically more interesting to investigate illusions to which schizophrenic patients fail to succumb - i.e. those where they make more accurate judgements than controls about the size of relevant parts of the stimuli. Happé (1996) found that autistic people were less likely than controls to succumb to the Ponzo, Kanisza triangle, Titchener, Hering and Poggendorff illusions, which are all stimuli that can be separated into an 'induced' component and an 'inducing' context. Little research has so far been done with these stimuli in schizophrenia, although the one study to date (Capozzoli & Marsh, 1994) did find that a group of paranoid schizophrenic patients was significantly less susceptible than normal controls to a 'perspective drawing' illusion, making more accurate judgements than controls about the lengths of lines in the stimulus. Capozzoli and Marsh did not illustrate their figure,

but it was probably similar to the Ponzo illusion, where perspective cues from two inwardly tilting lines lead a normal subject to judge that an upper horizontal line is longer than a lower one. In this regard, Capozzoli & Marsh's (1994) findings are consistent with those of Happé (1996) in autism, and support the hypothesis of weak central coherence in symptomatic schizophrenic patients.

It was shown earlier that autistic subjects perform better than controls on embedded figures tests in which hidden objects must be found within pictures (Jolliffe & Baron-Cohen, 1997; Shah & U. Frith, 1983), and this result was explained within the WCC model of autism. A number of studies have investigated the performance of schizophrenic patients on Witkin *et al.*'s (1971) adult embedded figures test (EFT), and contrary to predictions from a weak central coherence account of schizophrenia, patients typically perform poorly on this task. Magaro & Vojtisek (1971) found that chronic schizophrenic patients took longer than acute schizophrenics to find the hidden figures on the EFT, and both patient groups scored significantly worse than normals. Similar results were found by Vojtisek & Magaro (1974), who also showed that psychiatric controls performed significantly better than schizophrenic patients on the EFT.

These results are inconsistent with a WCC model of schizophrenia, but an important methodological issue should be considered. Both of the above studies administered the EFT using Witkin *et al.*'s (1971) standard procedure. In this, subjects are shown the to-be-found simple figure for 10 seconds, this is then removed, the complex figure is presented, and the subject begins searching. The methodology relies upon the

subject's ability to retain the simple figure in working memory during searching, but given evidence of impaired working memory in schizophrenia (e.g. Park & Holzman, 1992), it is perhaps not surprising that schizophrenic patients perform poorly on the task (Pickup, 1997). Autistic people also have working memory deficits and it is notable that Shah & U. Frith (1983), in their study of autistic performance on the Children's Embedded Figures Test, departed from Witkin *et al.*'s (1971) administration procedure and ensured that a picture of the to-be-found object was always present during searching. A prediction from this analysis, and a WCC account of schizophrenia, would therefore be that symptomatic schizophrenic patients should perform better than controls on embedded figures tests when the simple figures remain present during searching.

To investigate this hypothesis, Pickup (1997) devised a new embedded figures test for adults in which a different object was hidden within each of 8 different scenes. The test was administered to 37 schizophrenic patients, 17 psychiatric outpatients with diagnoses of anxiety or depression, and 30 normal volunteers, and subjects were asked to find the hidden objects as quickly as possible. In line with the above discussion, a picture of the to-be-found object was always present during searching. Pickup also included a measure of spatial IQ in his study (Raven's Advanced Progressive Matrices; Raven, 1958), as he argued that it was important to control for any spatial IQ differences between groups when investigating embedded figures performance. Pickup (1997) found that symptomatic schizophrenic patients (with either positive or negative symptoms) performed as well as controls at finding the

hidden objects. In contrast, remitted (symptom-free) schizophrenics scored significantly worse than normal controls on the task.

These results did not support the prediction of superior task performance by schizophrenic patients relative to controls, but they did provide some evidence that the symptoms of schizophrenia are associated with facilitation on embedded figures tests relative to the remitted schizophrenic condition. Pickup (1997) noted that all of the schizophrenic patients in his study (including the remitted group) were taking anti-psychotic medication, and he suggested that their task performance may have been compromised by non-specific effects associated with a present or past psychiatric illness, such as the adverse effects of medication on psychomotor speed. Pickup recommended that future research should attempt to control for these factors, and predicted that such methodology may reveal the embedded figures performance of remitted schizophrenic patients to be similar to that of control subjects, while symptomatic patients perform better than controls (in accord with a WCC account of schizophrenia).

The present study: Schizotypy and weak central coherence

It was shown in Section 1.2 that the schizotypy paradigm provides a useful means of testing models of psychosis without the potentially confounding effects of non-specific features of psychiatric illness. In the final part of the present study, therefore, the performance of normal participants assessed for schizotypy will be investigated on Pickup's (1997) embedded figures test. Participants will also complete a test of spatial

IQ so that any variation in IQ over the sample can be controlled. By analogy with the good performance of autistic individuals on embedded figures tests (Jolliffe & Baron-Cohen, 1997; Shah & U. Frith, 1983), it is predicted that good task performance will be particularly associated with schizotypal traits analogous to autistic features. These are the introvertive anhedonia, impulsive non-conformity, and cognitive disorganization components of schizotypy as measured by the O-LIFE questionnaire (Mason *et al.*, 1995). However, given the evidence discussed earlier that some of the positive symptoms of schizophrenia may also be associated with weak central coherence (e.g. delusions on the Block Design test: Robertson & Taylor, 1985; paranoid symptoms on an illusions task: Capozzoli & Marsh, 1994), it is possible that good embedded figures performance in normals may also be associated with high scores on the unusual experiences component of schizotypy.

As mentioned earlier, Happé (1994a; 1997) found no relationship between theory of mind and weak central coherence in her samples of autistic individuals, and she suggested on this basis that these two cognitive abilities are independent of one another in autism. By analogy with Happé's results, it is predicted that in the present study any variations in ToM and central coherence over the normal population will be unrelated.

1.5 SUMMARY OF THE PRESENT STUDY

This study uses the schizotypy paradigm to investigate two models of schizophrenia. The first is C. Frith's (1992) model which predicts that impairments in ToM, in

particular the ability to represent the mental states of other people, are associated with the negative and positive 'behavioural signs' and paranoid symptoms of schizophrenia. A sample of normal individuals will be assessed for schizotypy using the O-LIFE questionnaire, and each subject will then complete a story test of ToM, a verbal IQ test and two control tasks whose aim is to rule out alternative theoretical explanations of poor ToM task perfomance. The relationship between schizotypal traits and ToM will be investigated using both subgroup and correlational analyses. Following Langdon & Coltheart (1999), it is predicted that participants with a high total schizotypy score will perform worse on ToM tasks than those with a lower total score. On the basis of C. Frith's (1992) model and Pickup & C. Frith's (in press) study with schizophrenic patients, it is predicted that correlational and subgroup analyses will reveal an association between poorer ToM and high scores on the introvertive anhedonia, impulsive non-conformity and cognitive disorganization components of schizotypy. Subgroup analyses may further reveal a relationship between poorer ToM and high scores on the unusual experiences component of the O-LIFE.

The second part of the present study uses the schizotypy paradigm to investigate Pickup's (1997) suggestion that symptomatic schizophrenic patients may show 'weak central coherence' (WCC) as defined by U. Frith (1989) in the autism literature. The normal individuals assessed for schizotypy will complete Pickup's (1997) embedded figures test and a measure of spatial IQ, and it is predicted that good performance on the embedded figures test will be particularly associated with those schizotypal traits analogous to autistic features. These are the introvertive anhedonia, impulsive non-

conformity, and cognitive disorganization components of schizotypy as measured by the O-LIFE questionnaire. There may also be an association between good task performance and high scores for the unusual experiences component of schizotypy. By analogy with the work of Happé (1994a; 1997) in autism, it is expected that any variations in ToM ability and weak central coherence over the normal sample will be independent of one another.

CHAPTER 2: METHODS

2.1 PARTICIPANTS

Sixty-four normal subjects were recruited by sampling the UCL student population and associates of the researcher. An advertisement was also placed in the newsletter of a psychic studies organisation. General inclusion criteria were English as the first language, an age between 18 and 50 and no history of psychiatric illness or head injury. To ensure that the sample represented a broad range of schizotypy, a screening questionnaire was used to select participants for the study. The questionnaire used was the Schizotypal Personality Scale (STA) of the Claridge & Broks (1984) Schizotypy Questionnaire (STQ) (see Appendix 1). This is widely used as a screening measure and assesses schizotypal traits analogous to the positive symptoms of schizophrenia.

Subjects were classified as 'average' schizotypes if they scored within one standard deviation (SD) of the population mean on the STA. 'High' schizotypes scored more than 1 SD above the mean, and 'low' schizotypes scored more than 1 SD below the population mean. In total, 26 males and 38 females took part in the study. Their age ranged from 18 to 46 years (mean of 29.0 years). Sixteen participants fell within the 'low' range on the STA (7 males, 9 females; mean (SD) age = 28.8 (5.9)). Twenty-nine subjects fell within the 'average' STA range (13 males, 16 females; mean (SD)

age = 28.9 (5.8)). Nineteen participants fell within the 'high' range on the STA (6 males, 13 females; mean (SD) age = 29.4 (7.2)). A further 33 volunteers fell within the 'average' range, but were not asked to take part in the study because it was considered that enough 'average' participants had already been recruited. In addition, a further 5 volunteers were identified as suitable for the study by being 'low' or 'high' on the STA, but then failed to turn up for the interview appointment.

At the screening stage, subjects also completed the Lie Scale of the Short Form of the Eysenck Personality Questionnaire - Revised (EPQ-R; Eysenck & Eysenck, 1991). This consists of 12 questions (e.g. 'Have you ever said anything bad or nasty about anyone?') which assess subjects' tendency to 'fake good', i.e. to answer untruthfully in a socially desirable way. For the purposes of this study, the Lie Scale was built into the STA screening questionnaire such that every fourth question was a lie question (see Appendix 1). Any volunteer who scored more than 1 SD above the population mean on the Lie Scale was not included in the study, as high scores could mean that their responses were unreliable. All 64 participants discussed above scored in the normal range on the Lie Scale, but 8 people (3 males, 5 females) were rejected at the screening stage because of their high 'lie' scores.

2.2 MATERIALS

After passing the screening stage, participants completed the following questionnaire and tests in the order shown below:

The Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE)

This is a self-report measure of schizotypy devised by Mason *et al.* (1995) (see Appendix 1). It consists of between 24 and 30 questions on each of four scales of schizotypy, namely 'unusual experiences' (UE) (analogous to the positive symptoms of schizophrenia) and 'cognitive disorganization' (CD), 'impulsive non-conformity' (IN) and 'introvertive anhedonia' (IA) (analogous, in C. Frith's (1992) terminology, to the positive and negative 'behavioural signs' of schizophrenia). Internal consistency and test-retest reliability of the questionnaire were discussed on page 8 of the Introduction, and full psychometric data and norms for the O-LIFE are given in Mason *et al.* (1995).

It is usually found that the schizotypy scores of normal males and females differ, with females, for example, being more likely to endorse items analogous to the positive symptoms of schizophrenia and males endorsing more negative symptom items on schizotypy questionnaires (Claridge & Hewitt, 1987). This pattern was found by Mason *et al.* (1995) on the O-LIFE, where females endorsed more of the UE and CD items and males scored more highly on the IA items. Similarly, scores for the positive dimensions of schizotypy usually decrease with age, while those for negative dimensions increase with age (Claridge & Hewitt, 1987). Again, Mason *et al.* (1995) found this expected pattern on the O-LIFE questionnaire, with UE, CD and IN decreasing with age and IA increasing with age. These observed effects were used by Mason *et al.* (1995) to argue for the validity of the O-LIFE as a measure of schizotypy.

Participants obtained a raw score on each of the four schizotypy dimensions. Because of the effects of sex and age on schizotypy all of these scores were standardised for data analysis using the population norms provided by Mason *et al.* (1995).

Theory of mind (ToM) and 'physical' control stories

These materials comprised 16 short passages of text, followed in each case by a test question (see Appendix 2). The 8 stories testing representation of other people's mental states (ToM) were based on Happé's (1994b) 'Strange Stories', and were developed by Fletcher *et al.* (1995) for use with normal adults. They concerned double bluff, mistakes, persuasions and white lies, and were each followed by a question requiring an inference about a story character's thoughts and feelings. The 8 'physical' control stories were also developed by Fletcher *et al.* and required reasoning about situations in which people were involved, but in which mental state attribution was not necessary or relevant. These stories usually required inferences to be made about physical causation, for example the role of weather conditions in determining the outcome of air and land battles. Fletcher *et al.* showed that normals found the ToM and 'physical' stories equally difficult, and argued that the 'physical' stories provided a good control for the general reasoning component of ToM tasks.

Participants were told that they would be shown a number of short passages, and that they should read each passage to themselves until they felt they had understood it, at which point they should turn the page for the test question, the answer to which they should speak onto tape for later scoring. Participants were told that once they had

turned the page for the test question they could not turn back to the passage, so they were encouraged to spend as long as they needed studying the passage before turning over. Before the first story was presented, participants received a practice story. They were then presented with the 16 stories one-by-one in a written booklet. All stories of one type were given together, but the order of presentation of ToM or 'physical' stories was counterbalanced across subjects.

Time taken to read each story was recorded, as were participants' answers to the test questions. These answers were later transcribed from tape and rated according to standard criteria (obtained from F. Happé, personal communication). Ratings were carried out blind to participants' schizotypy scores. A second rater who was blind to the study hypotheses scored a random subset of 25 of the data sets, and agreement between raters was good (90%). Answers were scored 0, 1 or 2, with 2 being given for a full and explicitly correct answer and 1 for a partial or implicit answer. Examples of scoring criteria for the stories are given in Appendix 2. Subjects' use of mental state terms in their answers (e.g. "thinks", "knows") was also recorded, as was the 'order' of their response (e.g. first order: "She thought that . . ."; second-order: "He knew that Simon was a liar"; third-order: "He knew that the army would think he was lying").

The Quick Test

This is a short, standard measure of current verbal IQ developed by Ammons & Ammons (1962). There are three versions of the test (Forms 1, 2 and 3), and in each

version subjects are shown 4 pictures of complex scenes, and have to match each of 50 words to the most appropriate picture (e.g. 'current' is most appropriately matched to a countryside scene with a stream in it). Form 2 was used in the present study, and is shown in Appendix 3 together with the relevant word list. The Quick Test is thought to rely to some extent upon abstract reasoning rather than previously acquired knowledge (Ammons & Ammons, 1962), so is a good measure of current IQ rather than educational level or prior learning.

Ammons & Ammons (1962) provided percentile equivalents of raw scores on the test, based on the performance of 458 children and adults in the USA. They then converted the percentiles to IQ equivalents with a mean of 100 and SD of 15, so participants' test scores can be used to estimate Wechsler IQ (e.g. Wechsler, 1981). Reliability data for the Quick Test were supplied by Ammons & Ammons (1962), and for a sample of US white adults aged between 25 and 43, for example, the mean inter-form reliability was 0.86. Ammons and Ammons concluded that scores on single Forms of the test are suitably reliable for assessing intelligence at single age levels. Ammons & Ammons (1962) also provided validity data in terms of correlations of Quick Test scores with those from another recognised test of intelligence (the Full-Range Picture Vocabulary Test, FRPV; Ammons & Ammons, 1948). For the standardisation sample of US white adults the correlation of Quick Test Form 2 scores with the FRPV was 0.93, and Ammons and Ammons concluded that the test is valid as an estimate of current IQ.

The Cognitive Estimates Test

This is a short measure of executive function developed by Shallice & Evans (1978) and shown in Appendix 4. Participants were told that they would be asked 10 questions about facts which are not usually held as general knowledge, and that they should make a 'best guess' in answer to each question. Typical questions are 'How fast do race horses gallop?' and 'How many camels are there in Holland?' Participants were told that they could use appropriate units of their choice in responding (e.g. miles per hour or kilometres per hour), and conversion tables were used at the scoring stage to convert answers to the units given in the norms (taken from Lezak, 1995).

In scoring, subjects were given 0 if their answer fell within the acceptable range given in the norms (e.g. race horses gallop at between 15 and 40 mph), or scores of 1, 2 or 3 as the answer moved further away from the acceptable range (e.g. 'race horses gallop greater than 50 mph' scored 3). A total score of between 0 and 4 was classed as 'normal', a score of 4-6 was 'borderline', and 7 or greater was 'impaired'. Shallice & Evans (1978) found that patients with frontal lobe lesions were significantly more impaired on the test than patients with more posterior lesions, and they suggested that this reflected frontal patients' difficulty in generating responses or checking their appropriateness. While an 'impaired' score in the present sample does not necessarily indicate the presence of a frontal lesion, it does suggest that the participant has some difficulty generating appropriate responses and/or inhibiting inaccurate replies.

Short Form of Raven's Advanced Progressive Matrices

This is a short, standard measure of current non-verbal IQ developed by Raven (1958). An example of one of the stimuli is shown in Appendix 5. Subjects were shown 12 patterns, each of which had a piece missing. For each pattern, they were asked to choose from a selection of 8 the piece which completed the pattern. Participants were not timed while performing the test. Age-related norms are provided by Peck (1970), and were used to convert subjects' raw scores into non-verbal IQ scores with a mean of 100 and SD of 15.

Embedded Figures Test

This new test was designed for adults by Pickup (1997), and requires subjects to find a hidden object within each of 8 pictures. One of the stimuli from the test is shown in Appendix 6, together with its hidden object. Participants were told that they would be presented with pictures in which they had to find a hidden object as fast as they could. They were told that the to-be-found object would be shown by a laminated cardboard shape, which was the same size, shape and orientation as the object hidden in the picture. Participants were initially given 3 practice pictures, and any mistakes on these were corrected. For example, the instructions were re-iterated if subjects pointed to a hidden distractor object in the picture which was a different size or orientation to the cardboard shape. Participants were told that they could search for the object either by scanning the picture and pointing to the object or by moving the cardboard shape over the picture. The eight pictures were presented in the same order for every subject.

This was in order of increasing difficulty based on Pickup's (1997) pilot work with normal volunteers. There was a 2 minute time limit for each picture and if, after this time, the participant had not found the hidden object, they were shown its location. The number of objects successfully found was recorded, as was the mean time taken to find these objects.

2.3 PROCEDURE

Participants were tested individually on one occasion in a quiet room and were reimbursed for their time. The interview lasted about one hour. All subjects gave written, informed consent to take part in the study, which was approved by the Joint UCL/UCLH Committee on the Ethics of Human Research (see Appendix 7 for the letter of approval). The Volunteer Information Sheet and Consent Form are shown in Appendix 8. All participants completed the questionnaire and tests in the order given above.

CHAPTER 3: RESULTS

The first section of this chapter will examine participants' questionnaire responses. Scores on the ToM and control tasks, and their relation to the questionnaire responses will then be examined in section 3.2. Finally, subjects' performance on the embedded figures test will be analysed in section 3.3.

3.1 QUESTIONNAIRE DATA

Raw scores

Table 3.1 shows the mean, standard deviation (SD) and range of scores for the whole sample on the STA questionnaire, the lie scale and the O-LIFE subscales. An O-LIFE total score was calculated by summing the four subscale scores (UE + CD + IA + IN) for each participant, and is also shown.

Inspection of the distributions of scores showed an outlier of 20 (> 3 SD from the group mean) scored by one male on the introvertive anhedonia subscale. Following the method discussed by Howell (1997), this was changed to 17 (being one higher than the next highest score in the sample, i.e. 16), and was then no longer an outlier. The IA and Total scores in Table 3.1 have been adjusted to reflect this change. All

distributions of scores showed non-significant levels of skewness except for IA which, despite the above change, remained skewed.

Table 3.1 Mean, SD and range of questionnaire scores for the whole sample (N=64)

Scale	Mean (SD)	Range
STA	16.88 (8.62)	3 - 32
Lie scale	2.41 (1.56)	0 - 5
O-LIFE: Unusual experiences (UE)	11.81 (8.68)	0 - 27
O-LIFE: Cognitive disorganization (CD)	11.00 (5.84)	1 - 24
O-LIFE: Introvertive anhedonia (IA)	4.95 (4.21)	0 - 17
O-LIFE: Impulsive non-conformity (IN)	10.08 (3.82)	3 - 19
O-LIFE: Total score	37.84 (16.34)	10 - 82

As discussed in the Methods, schizotypy scores on standard questionnaires have been found to vary with sex, with females more likely to endorse traits analogous to the positive symptoms of schizophrenia and males scoring higher on negative symptom traits (e.g. Claridge & Hewitt, 1987). Table 3.2 presents descriptive statistics and t-statistics comparing the questionnaire scores of males and females in this sample.

Table 3.2 Mean, SD and range of scores on the questionnaires by sex

Scale	Males: Mean (SD) [Range]	Females:Mean (SD) [Range]	t (62)
STA	15.12 (8.10) [3 - 30]	18.08 (8.87) [4 - 32]	-1.36
Lie scale	2.42 (1.58) [0 - 5]	2.39 (1.57) [0 - 5]	0.07
O-LIFE: UE	9.42 (8.33) [0 - 26]	13.45 (8.63) [0 - 27]	-1.86
O-LIFE: CD	10.77 (6.19) [1 - 24]	11.16 (5.67) [1 - 21]	-0.26
O-LIFE: IA	6.15 (4.44) [1 - 17]	4.13 (3.90) [0 - 15]	1.93 *
O-LIFE: IN	10.27 (3.70) [4 - 17]	9.95 (3.95) [3 - 19]	0.33
O-LIFE: Total	36.62 (15.80) [17 - 82]	38.68 (16.86) [10 - 67]	-0.49

* $p < 0.05$, 1-tailed

The only significant sex difference was in scores on the IA subscale, with males scoring higher than females as predicted [t (62) = 1.93; p = 0.03, 1-tailed]. This difference was checked using the non-parametric Mann-Whitney test because of the skewed distribution of IA scores, and remained significant [U (64) = 335.5; p = 0.01, 1-tailed]. It should be noted that none of the group differences reached significance when a Bonferroni-corrected p-value of 0.007 (0.05/7) was used to correct for Type I error. However, trends in the data were in the predicted directions for all the schizotypy subscales, i.e. STA, UE and CD higher for females, and IA and IN higher for males (see Claridge & Hewitt, 1987; Mason *et al.*, 1995). There was no sex difference in the total O-LIFE score.

As discussed earlier, schizotypy scores also vary with age, and Mason *et al.* (1995) found that UE, CD and IN decreased significantly with age while IA increased with age. This relationship was investigated in the present sample by calculating Pearson's correlation coefficients between age and schizotypy score for each of the scales. These data are shown in Table 3.3.

Table 3.3 Pearson's correlations between age and schizotypy scores for whole sample

Scale	r (64)	1-tailed p-value
STA	- 0.07	0.16, ns
O-LIFE: UE	- 0.09	0.13, ns
O-LIFE: CD	- 0.21	0.03
O-LIFE: IA	- 0.12	0.08, ns
O-LIFE: IN	- 0.03	0.20, ns
O-LIFE: Total	- 0.16	0.06, ns

The only significant correlation was between age and CD subscale score where, as predicted, CD decreased with age. The other correlation coefficients failed to reach significance although those for STA, UE and IN were in the predicted direction. The Total O-LIFE score showed a trend to decrease with age. Contrary to predictions there was a tendency for the IA score to decrease with age. It should be noted that with a Bonferroni-corrected p-value of 0.05/6, none of these correlations reached statistical significance.

Standard scores on the O-LIFE questionnaire

As sex and age were associated with schizotypy scores in the present sample, Mason *et al.*'s (1995) sex and age norms for the O-LIFE subscales were used to calculate standard subscale scores for each participant [(score - mean score)/SD]. The Total O-LIFE score was then the sum of the standard scores. The data are shown by sex in Table 3.4.

Table 3.4 Mean, SD and range of standard scores on the O-LIFE subscales by sex

Scale	Mean (SD) Males [Range]	Mean (SD) Females [Range]	t (62)
O-LIFE: UE	0.19 (1.42) [- 1.45 - 3.15]	0.58 (1.34) [- 1.48 - 2.95]	- 1.09
O-LIFE: CD	0.06 (1.08) [-2.02 - 2.39]	- 0.06 (0.98) [-2.34 - 1.62]	0.46
O-LIFE: IA	- 0.22 (0.97) [-1.43 - 1.84]	- 0.31 (0.91) [-1.30 - 2.22]	0.38
O-LIFE: IN	0.27 (1.10) [-1.73 - 2.17]	0.44 (1.07) [-1.31 - 3.14]	- 0.60
O-LIFE: Total	0.31 (3.03) [-3.75 - 9.21]	0.65 (3.08) [-4.63 - 6.93]	-0.43

* $p < 0.05$, 2-tailed; ** $p < 0.01$, 2-tailed

It can be seen that standardisation removed the significant sex difference in raw IA subscale scores, and that both sexes were matched on all standard scores (including O-LIFE Total). All differences remained non-significant at the one-tailed level.

For the whole sample, Pearson's correlation coefficients were calculated between O-LIFE standard scores and age, and are shown in Table 3.5.

Table 3.5 Pearson's correlations between age and standard O-LIFE scores

Scale	r (64)	2-tailed p-value
O-LIFE: UE	0.06	0.64, ns
O-LIFE: CD	- 0.06	0.65, ns
O-LIFE: IA	- 0.26	0.04
O-LIFE: IN	0.20	0.12, ns
O-LIFE: Total	- 0.001	0.99, ns

It can be seen that standardisation removed the significant relationship between age and CD subscale score. However, there remained an effect of age in the standardised data, with scores on the IA subscale decreasing with age in the present sample. This effect did not reach statistical significance when a p-value of 0.01 (0.05/5) was used to control for Type I error. However, because of the possible effect of age, the age variable will be used as a covariate in subsequent analyses.

3.2 THEORY OF MIND (ToM) AND CONTROL TASKS

Scores on the story tasks

Two subjects were not tested on the ToM and physical stories, as they reported at interview that they were undergraduate psychology students and had some knowledge of the ToM concept. For the remaining 62 participants, the mean (SD) score on the ToM stories was 13.0 (1.9), with a range from 8 - 16. The mean (SD) score on the physical stories was 13.3 (1.9), with a range from 9 - 16. The sample as a whole therefore found both types of story equally difficult [within subjects t-test: $t(61) = -1.14$, $p = 0.26$, 2-tailed]. The mean (SD) verbal IQ for the 62 participants who provided story data was 102.9 (6.7). Mean (SD) score on the cognitive estimates task (the measure of executive function) was 4.0 (3.0). As discussed in the Methods, high scores on this latter task reflect poorer performance than low scores.

Analysis by median split

To enable direct comparison of the results with those of Langdon & Coltheart (1999), subjects were first subgrouped into 31 low schizotypal (low-S) and 31 high schizotypal (high-S) subjects using a median split of the O-LIFE Total standard score (median = 0.10). This was done across all subjects as the Total standard score did not differ significantly for males and females. Scores of these two groups on the story tasks are shown in Table 3.6.

Table 3.6 Mean (SD) scores of high-S and low-S subgroups on the story tasks

Group	Mean (SD) [Range] ToM stories	Mean (SD) [Range] Physical stories
High-S	12.6 (2.2) [8 - 16]	12.9 (2.2) [9 - 16]
Low-S	13.4 (1.5) [10 - 16]	13.7 (1.5) [10 - 16]

Distributions of scores in both groups showed non-significant levels of skewness, so a two-way mixed analysis of variance (ANOVA) with two levels on the between factor of subject group (low-S vs. high-S) and two levels on the repeated factor of story type (ToM vs. physical) was used to test differences in mean task score. The main effect of story type was not significant [$F(1, 60) = 1.29$; $p = 0.26$], reflecting the fact that subjects found both sets of stories equally difficult. The main effect of subject group approached significance [$F(1, 60) = 3.73$; $p = 0.06$] but the story type x group interaction was not significant [$F(1, 60) = 0.02$, $p = 0.89$]. The main effect of group reflected a trend for the high-S participants to score more poorly than low-S subjects on both types of story [ToM: $t(60) = 1.73$; $p = 0.09$; physical: $t(60) = 1.59$; $p = 0.12$].

To check for any moderating effects of age, verbal IQ or executive function on the effect of group on task score, the above analysis was repeated using these three variables as covariates. For the high-S and low-S groups, the mean (SD) age, verbal IQ and cognitive estimates score are shown in Table 3.7. With independent samples t-tests, these variables did not differ significantly between groups (all $p > 0.23$).

Table 3.7 Mean values of age (yrs), verbal IQ and cognitive estimates score by group

Group	Mean (SD) [Range] Age	Mean (SD) [Range] Verbal IQ	Mean (SD) [Range] cog. estimates score
High-S	28.0 (6.3) [18 - 38]	102.2 (7.5) [87 - 120]	4.5 (3.3) [0 - 12]
Low-S	29.8 (6.1) [19 - 46]	103.5 (5.8) [91 - 116]	3.6 (2.6) [0 - 11]

All distributions of the variables in Table 3.7 showed non-significant levels of skewness except for scores on the cognitive estimates task which were positively skewed. These were transformed for analysis using score = log (score + 1), which removed the skewness. When the above mixed ANOVA was repeated with age, verbal IQ and transformed cognitive estimates score as covariates, the main effect of subject group still approached significance [$F(1, 54) = 3.20$; $p = 0.08$], and the main effect of story type remained non-significant [$F(1, 54) = 0.08$; $p = 0.79$] as did the story type x group interaction [$F(1, 54) = 0.03$; $p = 0.86$]. All interactions between group and covariates were non-significant, showing that they were not having a moderating effect on task performance [age x group: $F(2, 54) = 0.49$; $p = 0.62$; verbal IQ x group: $F(2, 54) = 2.77$; $p = 0.07$; cognitive estimates score x group: $F(2, 54) = 0.41$; $p = 0.67$].

Analysis using subjects with extreme schizotypy scores

As about a third of subjects in the above analyses had O-LIFE Total standard scores with an absolute value (modulus) less than 1, the analysis was repeated using only

those participants whose O-LIFE Total standard score was greater than 1 or less than -1, in order to see whether any effects of schizotypy on task performance were limited to the extremes of the sample. This resulted in two new subject groups, highest-S (N = 24) and lowest-S (N = 22). It should be noted that re-analysing the data in this way considerably increases the chance of Type I error, so p-values were corrected as appropriate if any results appeared significant. Scores of the highest-S and lowest-S groups on the story tasks are shown in Table 3.8.

Table 3.8 Mean (SD) scores of highest-S and lowest-S subgroups on the story tasks

Group	Mean (SD) [Range] ToM stories	Mean (SD) [Range] Physical stories
Highest-S	12.7 (2.1) [8 - 16]	13.1 (2.2) [10 - 16]
Lowest-S	13.8 (1.2) [12 - 16]	13.5 (1.3) [10 - 16]

Distributions of scores in both groups showed non-significant levels of skewness, so a two-way mixed analysis of variance (ANOVA) with two levels on the between factor of subject group (lowest-S vs. highest-S) and two levels on the repeated factor of story type (ToM vs. physical) was used to test differences in mean task score. As with previous analyses, the main effect of story type was not significant [$F(1, 44) = 0.04$; $p = 0.85$]. The main effect of subject group showed a trend towards significance [$F(1, 44) = 2.78$; $p = 0.10$], but the story type x group interaction was not significant [$F(1, 44) = 1.35$, $p = 0.25$]. The main effect of group reflected a tendency for the highest-S

participants to score more poorly than lowest-S on both types of story [ToM: t (44) = 2.14; p = 0.04; physical: t (44) = 0.77; p = 0.44].

To check for any moderating effects of age, verbal IQ or executive function on the effect of group on task score, the above analysis was repeated using these three variables as covariates. There were no significant effects, confirming that the variables were not significant moderators [group: F (1, 38) = 2.01; p = 0.16; story type: F (1, 38) = 0.002; p = 0.96; story type x group: F (1, 38) = 0.52; p = 0.48; age x group: F(2, 38) = 0.51; p = 0.61; verbal IQ x group: F(2, 38) = 1.60; p = 0.22; cognitive estimates score x group: F(2, 38) = 0.73; p = 0.49].

Analysis using schizotypy subgroups

On the basis of C. Frith's (1992) model of schizophrenia (discussed in Section 1.3), further group analyses were carried out to test the prediction that schizotypal traits analogous to the 'behavioural signs' and positive symptoms of schizophrenia would be specifically associated with poorer performance on ToM tasks. Because of the increased risk of Type I error associated with these additional comparisons, it was recognised that any significant results should be interpreted using a conservative alpha. By analogy with C. Frith's studies on schizophrenic patients (reviewed in the Introduction), participants were allocated to the 'behavioural signs' (Beh) subgroup if their sum of standard scores on the IA, IN and CD subscales of the O-LIFE was greater than 1. This produced a subgroup of 18 subjects. Remaining participants were then placed in the 'positive symptoms' (Pos) subgroup if their standard score on the

UE subscale was greater than 1. There were 11 subjects in this subgroup. Any participants who had not yet been classified were allocated to the 'no symptoms' (None) subgroup. This contained 33 subjects. Scores on the story tasks by subgroup are shown in Table 3.9:

Table 3.9 Mean (SD) scores of schizotypy subgroups on the story tasks

Group	Mean (SD) [Range] ToM stories	Mean (SD) [Range] Physical stories
Beh	13.2 (1.9) [9 - 16]	13.3 (2.3) [9 - 16]
Pos	12.0 (2.4) [8 - 15]	13.1 (1.9) [10 - 16]
None	13.2 (1.7) [9 - 16]	13.3 (1.7) [10 - 16]

Inspection of the data showed that the Pos subgroup had a somewhat lower ToM score than the other groups, while all participants scored equally on the physical stories. As distributions of scores in all groups showed non-significant levels of skewness, the statistical significance of this difference was investigated as in previous analyses using a two-way mixed ANOVA. This time there were three levels on the between factor of subject group (Beh vs. Pos. vs. None) and two levels on the repeated factor of story type (ToM vs. physical). As with previous analyses, the main effect of story type was not significant [$F(1, 59) = 2.38$; $p = 0.13$]. The main effect of subject group was also non-significant [$F(2, 59) = 0.78$; $p = 0.46$], as was the story type x group interaction [$F(2, 59) = 1.12$, $p = 0.33$]. As before, the potential moderating effects of age, verbal IQ or executive function on the effect of group were

investigated, and all interaction terms between these covariates and group were non-significant (all $p > 0.15$). Contrary to predictions based on C. Frith's model, these results showed no association between poorer ToM and schizotypal traits analogous to the behavioural signs or positive symptoms of schizophrenia.

Regression analysis

One problem with the above subgroup analysis is that statistical power was reduced by forming the three subgroups of participants. There were only 11 subjects in the Pos subgroup, so it is possible that there was insufficient power to detect any association between scores for 'unusual experiences' and performance on the story tasks. Although all the analyses so far had not revealed any significant association between schizotypy and task performance, it was decided to use regression analysis to check C. Frith's (1992) predictions of poorer ToM being specifically associated with schizotypal traits analogous to the behavioural signs and positive symptoms of schizophrenia. By using scores of the whole sample on all of the O-LIFE subscales, this analysis had greater statistical power than the above subgroup comparison.

Examination of scores for the whole sample on the story tasks showed that scores on the ToM stories were significantly negatively skewed. This was not a problem in earlier group analyses because ToM scores for each group were always non-significantly skewed. In order that scores met the assumptions of normality required for linear regression, all ToM scores were transformed by taking the square root of the reflected score, so that score = - 1 x sqrt [(score x - 1) + 16]. This removed the

skewness. Pearson's correlation coefficients were then calculated between each subject's standard score on the UE, CD, IA and IN subscales of the O-LIFE, and their scores on the ToM (transformed score) and physical stories. Story scores were also correlated with verbal IQ and the log transformed cognitive estimates score, to confirm that these two variables were not associated with task performance. An alpha of 0.004 (0.05/12) was used to correct for multiple comparisons, and with this criterion all correlations were non-significant. The correlation between UE and ToM score approached significance [$r\ (62) = -0.33$; $p = 0.009$], while for all other correlations p was greater than 0.10.

As C. Frith's (1992) model of schizophrenia predicts that poorer ToM is associated most strongly with 'behavioural signs', and less strongly with paranoid symptoms, hierarchical multiple regression was used to enter a 'behavioural signs' (Beh) schizotypy composite (standard IA + standard IN + standard CD) on step 1, and a 'positive symptoms' (Pos) schizotypy score (standard UE) on step 2, as predictors of story score. Separate regressions were performed with the transformed ToM score or physical stories score as the dependent variable. Both regressions met the assumption of homogeneity of variance, had normal distributions of standardized residuals and showed no influence of outliers (all Cook's distance and DfFit < 0.20). The regression models are shown in Table 3.10.

Contrary to Frith's (1992) hypothesis there was no association between performance on the ToM task and schizotypal traits analogous to the behavioural signs of schizophrenia. However, scores on the UE subscale of the O-LIFE (analogous to

positive psychotic symptoms) were significant predictors of ToM score [Beta (Pos) = - 0.383; p = 0.009]. Addition of UE into the model produced a significant increase in the proportion of variance explained [F (1, 59) = 7.42; p = 0.008]. This is consistent with Frith's model, and the fact that the UE scale did not predict performance on the physical stories [Beta (Pos) = - 0.169; p = 0.254] suggests that the result reflected a specific difficulty with mental state attribution in participants with high UE scores.

Table 3.10 Hierarchical multiple regression of story task scores on 'Beh' and 'Pos'

Regression model	ToM stories	Physical stories
R^2 (Beh only)	0.006	0.029
F (1, 60)	0.38, p = 0.541, ns	1.82; p = 0.183, ns
Beta (Beh)	- 0.079; p = 0.541, ns	- 0.171; p = 0.183, ns
R^2 (Beh + Pos)	**0.117**	0.051
F (2, 59)	**3.89, p = 0.026**	1.58; p = 0.215, ns
Beta (Beh)	0.112; p = 0.430, ns	- 0.087; p = 0.554, ns
Beta (Pos)	**- 0.383; p = 0.009**	- 0.169; p = 0.254, ns
F_{inc} (1, 59)	**7.42; p = 0.008**	1.37; p = 0.247, ns

Analysis of reading times on the story tasks

The mean (SD) times (in seconds) taken by participants to read the ToM and physical stories were 21.9 (6.9) and 26.8 (8.5) respectively. Both distributions of times had no outliers but were significantly positively skewed, so log transformations were carried out to reduce skewness. On the basis of C. Frith's (1992) model, it was predicted that high schizotypy would be associated with poorer ToM, which may manifest as longer reading times on the ToM stories than on the physical stories. By analogy with the

above analyses, the time data were explored using both subgroup and regression analysis.

Median split analysis

Participants were divided into high-S and low-S groups based on a median split of their Total schizotypy standard score on the O-LIFE. A two-way mixed ANOVA with two levels on the between factor of subject group (high-S vs. low-S) and two levels on the within factor of story type (ToM vs. physical), revealed a significant main effect of story [$F(1, 60) = 58.55$; $p < 0.001$], reflecting the fact that participants took longer to read the physical stories than the ToM stories. However, there was no significant main effect of group [$F(1, 60) = 0.53$; $p = 0.47$], and no significant story type x group interaction [$F(1, 60) = 0.28$; $p = 0.60$]. These data therefore provided no evidence that Total schizotypy score was associated with reading time on either set of stories.

Potential moderating effects of age, verbal IQ and executive function were investigated by repeating the analysis with these as covariates. The main effect of story type was now non-significant [$F(1, 54) = 2.28$; $p = 0.14$], as were the main effect of group [$F(1, 54) = 0.31$; $p = 0.58$] and the story type x group interaction [$F(1, 54) = 0.95$; $p = 0.33$]. The interactions between group and age [$F(2, 54) = 0.49$; $p = 0.61$] and group and executive function [$F(2, 54) = 1.93$; $p = 0.16$] were non-significant, but the group x verbal IQ interaction was highly significant [$F(2, 54) = 5.95$; $p = 0.005$], showing that verbal IQ was a moderator of participants' reading

time. As this analysis removed the significant main effect of story, it is apparent that the amount of extra time required by participants to read the physical stories compared to the ToM stories was related to their verbal IQ.

Regression analysis

Pearson's correlation coefficients were calculated between each subject's standard score on the UE, CD, IA and IN subscales of the O-LIFE, and their log transformed reading times on the ToM and physical stories. The times were also correlated with verbal IQ and the log transformed measure of executive function. To correct for the increased chance of Type I error, a conservative p value of 0.004 (0.05/12) was used. In line with the moderating effect of verbal IQ on reading time (discussed above), the correlation between IQ and time was significant for the physical stories [r (62) = - 0.42; p = 0.001] and approached significance for the ToM stories [r (62) = - 0.33; p = 0.009]. These effects reflected reduced reading time with higher IQ. There was also a significant negative correlation between standard score on the IN subscale and reading time for the physical stories [r (62) = - 0.41; p = 0.001], and the effect approached significance for the ToM stories [r (62) = - 0.34; p = 0.007]. These latter associations were not predicted a priori and will be explored in the Discussion. All other correlations were non-significant (all $p > 0.10$).

As C. Frith's (1992) model suggests that poorer ToM is associated with the behavioural signs and paranoid symptoms of schizophrenia, it was predicted that participants with high scores for schizotypal traits analogous to these symptoms

would take longer to read the ToM stories than those subjects with low scores. As before, hierarchical multiple regression was used to enter a 'behavioural signs' (Beh) schizotypy composite (standard IA + standard IN + standard CD) on step 1, and a 'positive symptoms' (Pos) schizotypy score (standard UE) on step 2, as predictors of reading time. Verbal IQ was entered on step 3 because of its correlation with time identified above. Separate regressions were performed with the log transformed reading time on the ToM stories or the physical stories as the dependent variable. Both analyses met the assumption of homogeneity of variance, had normal distributions of standardized residuals and showed no influence of outliers (all Cook's distance and DfFit < 0.22). The regression models are shown in Table 3.11.

Table 3.11 Hierarchical multiple regression of reading times on 'Beh', 'Pos' and IQ

Regression model	ToM stories	Physical stories
R^2 (Beh only)	0.028	0.040
F (1, 60)	1.71, p = 0.196, ns	2.53; p = 0.117, ns
Beta (Beh)	- 0.167; p = 0.196, ns	- 0.201; p = 0.117, ns
R^2 (Beh + Pos)	0.051	0.060
F (2, 59)	1.59, p = 0.213, ns	1.89; p = 0.160, ns
Beta (Beh)	- 0.255; p = 0.087, ns	- 0.282; p = 0.057, ns
Beta (Pos)	0.176; p = 0.234, ns	0.163; p = 0.269, ns
R^2 (Beh + Pos + IQ)	**0.138**	**0.210**
F (3, 58)	**3.11; p = 0.033**	**5.15; p = 0.003**
Beta (Beh)	- 0.203; p = 0.159, ns	- 0.215; p = 0.120, ns
Beta (Pos)	0.119; p = 0.406, ns	0.088; p = 0.520, ns
Beta (IQ)	**- 0.301; p = 0.018**	**- 0.394; p = 0.002**
F_{inc} (1, 58)	**5.85; p = 0.019**	**11.01; p = 0.002**

As can be seen from this table, no support was found for the hypothesis that schizotypal traits analogous to behavioural signs or positive symptoms would predict slower reading times on the ToM task. In fact, scores for these traits did not account for a significant proportion of variance in the times on either task. For both sets of stories, a significant increase in model fit only occurred when verbal IQ was added to the model [ToM: $F(1, 58) = 5.85$; $p = 0.019$; physical: $F(1, 58) = 11.01$; $p = 0.002$], confirming the strong effect of IQ on reading time in the present sample.

Analysis of mental state language in responses to the ToM stories

The final analysis of the story data examined participants' use of mental state language in their responses to the ToM stories. On the basis of C. Frith's (1992) model, it was predicted that high schizotypy scores (in particular high scores for traits analogous to the behavioural signs and positive symptoms of schizophrenia), would be associated with less use of mental state terms in responses. Each time a participant used a second-order attribution (e.g. "He thinks that he's lying"), they were given 2 points. Similarly they were awarded 3 points each time they used a third-order mental state term (e.g. "He thinks that the army will expect him to lie"). The number of points was added for each subject to give a mental state score. The distribution of these scores over the whole sample had one outlier (19), which was changed to 16 (i.e. one higher than the next highest score). The mean (SD) mental state score was then 5.7 (3.6) [Range 0 - 16]. The scores were significantly positively skewed and were square root transformed for analysis.

By analogy with earlier analyses, participants were grouped into high-S and low-S subgroups based on a median split of their Total schizotypy standard score on the O-LIFE. These groups did not differ significantly on mental state score [t (60) = - 0.15; p = 0.88]. For the whole sample, Pearson's correlation coefficients were then calculated between mental state score and standard scores on the UE, CD, IA and IN subscales of the O-LIFE. Verbal IQ and the transformed measure of executive function were also correlated with mental state score. Because of the increased risk of Type I error associated with these multiple comparisons, a conservative p value of 0.008 (0.05/6) was adopted. All correlations were non-significant (all $p > 0.10$), so there was no evidence for an association between schizotypal traits and the use of mental state language.

3.3 PERFORMANCE ON THE EMBEDDED FIGURES TASK (EFT)

All 64 participants provided data on the EFT, but only 62 gave spatial IQ data on the Raven's matrices test, as time limitations on two of the interviews meant that this task was omitted. The mean (SD) spatial IQ for the whole sample was 109.4 (12.8) [Range 80 - 125], and as the distribution of IQs was significantly skewed, the scores were square root transformed for analysis. The EFT provided two dependent variables - the accuracy of performance (i.e. the number of hidden figures correctly located within the time limit, maximum = 8), and the mean time taken to find the correctly located figures. As discussed in Section 1.4, it was predicted that high schizotypy would be associated with better performance on the task than low schizotypy. In particular, it was expected that the best scores would be shown by

participants scoring high on schizotypal traits analogous to autistic features (i.e. the IA, IN and CD subscales of the O-LIFE).

Accuracy of EFT performance

Accuracy scores ranged between 5 and 8, although the single score of 5 was an outlier and was changed to 6 for the purpose of analysis. The mean (SD) accuracy over the whole sample was then 7.5 (0.6). The distribution of scores remained significantly negatively skewed, so scores were transformed for analysis using score = - 1 x sqrt [(- 1 x score) + 8], which removed the skewness.

As with the earlier analyses of story data, the effect of total schizotypy score on EFT performance was investigated by dividing subjects into high-S and low-S groups using a median split of Total schizotypy standard score on the O-LIFE. The mean (SD) spatial IQs of the high-S and low-S groups were 110.7 (11.9) and 108.1 (13.6) respectively, and these did not differ significantly [t (60) = - 0.503; p = 0.62]. The EFT accuracy of the high-S and low-S groups is shown in Table 3.12.

Table 3.12 Mean (SD) accuracy of high-S and low-S subgroups on the EFT

Group	Mean (SD) accuracy
High-S (N = 32)	7.53 (0.62)
Low-S (N = 32)	7.47 (0.67)

When these scores were compared using an independent samples t-test on the transformed data, the groups did not differ significantly in accuracy [t (62) = - 0.32; p = 0.75].

As with earlier analyses, the EFT accuracy of the highest-S and lowest-S subgroups was also investigated, to check whether any effects of schizotypy were limited to the extremes of the sample. Participants in these groups were all those for whom the absolute value of the Total schizotypy standard score was greater than 1. Because of the greater risk of Type I error associated with this additional comparison, it was recognised that a conservative alpha should be adopted for the analysis. EFT accuracy of the 2 groups is shown in Table 3.13, and again did not differ significantly between groups [t (46) = - 0.76; p = 0.45].

Table 3.13 Mean (SD) accuracy of highest-S and lowest-S subgroups on the EFT

Group	Mean (SD) accuracy
Highest-S (N = 25)	7.56 (0.65)
Lowest-S (N = 23)	7.43 (0.66)

To investigate the association between particular schizotypal traits and EFT accuracy, Pearson's correlation coefficients were calculated between the standard UE, CD, IN and IA subscales of the O-LIFE and the transformed accuracy score. A 'behavioural signs' composite of (IA + IN + CD) was also correlated with accuracy, as was spatial

IQ. To control for Type I error, a corrected p-value of 0.008 (0.05/6) was used. With this criterion all correlations were non-significant, although the correlation between spatial IQ and accuracy approached significance [r (62) = 0.29; p = 0.025], reflecting greater accuracy with higher IQ. There was therefore no evidence that better accuracy on the task was associated with particular schizotypal traits (all $p > 0.31$).

Analysis of search times on the EFT

The mean time (in seconds) taken by subjects to correctly locate the hidden figures was 23.6 (10.5) [Range 6.6 - 52.3]. There were no outliers and the distribution was not significantly skewed. Any effect of total schizotypy score on search time was investigated by comparing the mean search times of the high-S and low-S groups. These are shown in Table 3.14, and did not differ significantly [t (62) = 1.10; p = 0.27]. Similarly, the mean search times of the highest-S and lowest-S groups did not differ [t (46) = 1.33; p = 0.19].

Table 3.14 Mean (SD) search times of high-S and low-S subgroups on the EFT

Group	Mean (SD) time / secs
High-S (N = 32)	22.2 (9.4)
Low-S (N = 32)	25.1 (11.4)

Any associations between particular schizotypal traits and search time were investigated by calculating Pearson's correlation coefficients between time and the standard UE, CD, IA and IN subscales of the O-LIFE. The (IA + IN + CD) composite was also correlated with time, as was spatial IQ. A Bonferroni-corrected p-value of 0.008 (0.05/6) was used to correct for Type I error, and all correlations were non-significant (all $p > 0.10$). The largest correlation coefficient was $r(64) = -0.21$; $p = 0.11$, 2-tailed, for the association between search time and score on the introvertive anhedonia (IA) subscale of the O-LIFE.

3.4 CORRELATION BETWEEN ToM SCORES AND EFT SCORES

As discussed in the Introduction, it was predicted on the basis of existing studies in autism that ToM ability and 'weak central coherence' as tapped by the EFT would be uncorrelated in the present study. As no evidence of weak central coherence emerged in the present sample, it was not considered meaningful to do this correlation.

CHAPTER 4: DISCUSSION

This study investigated two separate psychological models of schizophrenia using the schizotypy paradigm. This approach assumes a continuum of psychosis-proneness within the normal population, and predicts that any cognitive abnormalities associated with psychotic illness will be present in highly schizotypal healthy people, but to a lesser extent than in people who are actually ill. On the basis of C. Frith's (1992) cognitive neuropsychological model of schizophrenia, and Pickup's (1997) extension of the 'weak central coherence' account of autism into schizophrenia, it was predicted that high schizotypy would be associated with poor performance on tests of theory of mind (ToM), and with good performance on an embedded figures test. Discussion will focus firstly on the schizotypy questionnaires used in the study, and will then consider the ToM and embedded figures results in the light of theory and previous studies. Limitations of the present study, and suggestions for future work, will be noted throughout the Discussion where appropriate.

4.1 QUESTIONNAIRE DATA

Two schizotypy questionnaires were administered to participants in this study. The first (STA; Claridge & Broks, 1984) asked mainly about schizotypal traits analogous to the positive symptoms of schizophrenia, and was used as a screening measure to ensure a broad range of schizotypy within the sample. The second questionnaire (O-

LIFE) was developed by Mason *et al.* (1995) in order to assess schizotypal traits along each of the four dimensions identified in previous factor analytic studies (e.g. Claridge *et al.*, 1996). These were 'unusual experiences' (UE) (analogous to the positive symptoms of schizophrenia such as hallucinations and delusions of reference or passivity), and 'cognitive disorganization' (CD), 'impulsive non-conformity' (IN) and 'introvertive anhedonia' (IA), analogous, in C. Frith's (1992) terminology, to the positive and negative 'behavioural signs' of schizophrenia such as inappropriate speech, affect or behaviour (CD and IN) and poverty of speech, social withdrawal and anhedonia (IA).

Sex differences on the questionnaires

On the basis of previous studies (e.g. Claridge & Hewitt, 1987; Mason *et al.*, 1995), it was expected that participants in the present study would show sex differences in their responses to the questionnaires. It was predicted that females would be more likely than males to report positive schizotypal traits, and that males would score higher on negative traits. Trends in the present study largely supported these predictions, although none of the effects reached statistical significance when alpha was corrected for multiple comparisons. Females tended to score higher than males on the STA measure and on the UE and CD scales of the O-LIFE (consistent with the significant differences found by Claridge & Hewitt (1987) and Mason *et al.* (1995)). Similarly, males in the present sample tended to score higher on the IA and IN scales of the O-LIFE, consistent with the findings of Mason *et al.* (1995). It should be noted that the sample size here was small compared to the studies in which significant sex

differences were found, and the following power calculation shows that the statistical power to detect differences was low in the present study:

From Mason *et al.*'s (1995) data, the mean (SD) score of their 508 subjects on the UE scale of the O-LIFE was 9.7 (6.7). This broke down by sex as males: 8.70 (6.24) and females: 10.51 (6.58), which gives an estimate of the effect size (d) of 0.282. Using the equation

$$\delta = d \surd (N_h / 2)$$

where N_h is the harmonic mean of sample size, gives a value of δ for the present study (with 26 males and 38 females) of 1.108. From tables, this corresponds approximately to a power of 0.29 to detect a sex difference in UE at $p < 0.05$ with a one-tailed test. This power was considerably less than the conventionally required value of 0.80, so it is not surprising that sex differences failed to reach statistical significance in this study. Having said that, some of the trends in the present data were quite large considering the small sample size, and this probably reflected the fact that the sample was non-randomly selected from the normal population in order to represent a broad range of schizotypy.

The effect of sex on responses to the O-LIFE was controlled for by standardising the questionnaire scores against Mason *et al.*'s (1995) norms. This effectively removed the above trends in the data.

Effects of age on questionnaire responses

On the basis of the studies by Claridge & Hewitt (1987) and Mason *et al.* (1995), it was similarly expected that age of participants would be associated with self-reported schizotypy in the present study. Scores on STA, UE, CD and IN were expected to decrease with age, while scores on IA should increase with age. Trends in the STA, UE, CD and IN data supported these predictions, although none of the effects reached statistical significance when alpha was corrected for multiple comparisons. Again, this probably reflected low statistical power associated with the relatively small sample size in the present study. Standardisation of the data against Mason *et al.*'s (1995) norms for the O-LIFE removed the above age-related trends as expected.

Participants' IA scores showed an unexpected trend to decrease with age, and when the scores were standardised against Mason *et al.*'s (1995) norms, this effect approached statistical significance. This finding probably reflected a selection bias in the present sample, with the younger participants tending to be more introvertive than the older subjects. It is difficult to explain why this occurred, although it may be relevant that many of the older participants were friends or associates of the researcher, while many of the younger participants were undergraduate students. It may be that associates of the researcher were, on average, more extrovert, pleasure-seeking or socially involved than people of the same age in the general population. Whatever the reason, it is unlikely that this age effect influenced the results of the study in any way, as age showed no significant contribution to the variance in task performance when used as a covariate in the analyses.

The meaning of sex and age differences in schizotypy

The sex and age effects usually found on schizotypy measures have some similarity to effects within schizophrenic populations, and add weight to the argument that normal schizotypy lies on a continuum with psychotic illness. For example, in a latent class analysis of 447 schizophrenic patients, Castle *et al.* (1994) found that a subgroup of patients with negative symptoms was predominantly male, whereas a 'paranoid' subgroup with mainly positive symptoms had a greater proportion of females. Similarly, longitudinal studies of schizophrenic patients (reviewed by McKenna, 1994) show that patients typically present at their first breakdown with positive symptoms, but that with increasing age and chronicity of illness there is a reduction in positive symptomatology and an increase in negative symptoms. As discussed by Mason *et al.* (1995), it is important to bear in mind that little research has so far been done on the association between sex, age, schizotypal traits and schizophrenic symptoms, and it is possible, for example, that factors such as gender role or identity have some association with responses on schizotypy questionnaires over and above sex per se. Further studies are needed in which participants complete schizotypy and gender role questionnaires, in order to tease apart the relative contributions of gender role and sex to self-reported schizotypy.

4.2 THEORY OF MIND (ToM) AND CONTROL TASKS

In the present study, participants were given 8 ToM and 8 'physical' control stories which were developed by Fletcher *et al.* (1995) for use with normal adults. Like the

ToM stories, the physical stories required both comprehension of information and the drawing of inferences beyond the information stated; however only the ToM stories required attribution of mental states. The purpose of the physical stories was twofold. Firstly, they provided a control for the general reasoning component of the ToM stories, and secondly they controlled for the possibility that poor performance on ToM tasks reflects problems imagining abstract or hypothetical states of affairs (Currie, 1996; Harris, 1995). It was predicted that if subjects had specific difficulties attributing mental states, they would perform more poorly on the ToM stories than on the physical stories.

Two other verbal control tasks were used in the present study. The Quick Test (Ammons & Ammons, 1962) estimated participants' current verbal IQ and controlled for the possible influence of general intelligence on task performance. The Cognitive Estimates Test (Shallice & Evans, 1978) is a recognised measure of executive function, and was used to control for the possibility that poor performance on ToM tasks reflected executive difficulties rather than a specific problem attributing mental states. Control for executive function was important for two reasons. Firstly, a number of studies have found an association between high schizotypy and poor performance on executive tests (e.g. Lenzenweger & Korfine, 1994; Obiols *et al.*, 1997; Raine *et al.*, 1992), so it was important to show that any association between schizotypy and ToM in the present sample was not simply a reflection of executive ability. Secondly, and more specifically, Russell and colleagues (e.g. Russell, 1998) have argued that poor performance on ToM tasks reflects a particular executive impairment in being 'captured' by salient information and failing to inhibit responses

based on that information. It was felt in the present study that the Cognitive Estimates test provided a reasonable control for this executive ability, as when generating responses on this task subjects often need to inhibit their initial or 'impulsive' guess in order to produce a reasoned estimate. It was predicted that if participants' poor performance on ToM tasks reflected executive impairments rather than difficulties attributing mental states, a significant association would appear between scores on the ToM and Cognitive Estimates tasks.

The first part of this section will consider scores on the story tasks in light of the study hypotheses and previous work. Story reading times and participants' use of mental state language will then be discussed in later sections.

Scores on the story tasks

In a pilot study with the ToM and physical stories, Fletcher *et al.* (1995) showed that a sample of 60 normal adults found both sets of stories equally difficult [Mean (SD) scores were ToM: 12.9 (1.9); physical: 12.8 (2.0)]. This result was replicated in the present study, where the sample as a whole scored very similarly to Fletcher *et al.*'s subjects. This is important as it shows that there were no ceiling effects in participants' scores on the stories, and an acceptable range of scores was obtained. In addition, the equal difficulty of the tasks meant that any differences between subjects' performance on the ToM and physical stories in the present study could not be attributed to the psychometric properties of the tasks.

On the basis of C. Frith's (1992) model of schizophrenia and the results of Langdon & Coltheart (1999) with a sample of normal adults assessed for schizotypy, it was predicted that when the present sample was divided according to schizotypy scores, differences in ToM ability would emerge. Firstly, it was expected that subjects with a high total schizotypy score would perform more poorly on the ToM stories than those with a low total schizotypy score, but that both groups would score equally on the physical stories. This was an attempted replication of Langdon & Coltheart's (1999) finding that high schizotypes scored worse than low schizotypes in the false belief condition of a picture-sequencing task, but that both groups scored equally in other task conditions. The prediction was not supported in the present study, either when data were analysed using a median split of participants into high or low schizotypes, or when only the highest and lowest schizotypes were included. In both of these analyses there was a non-significant tendency for highly schizotypal subjects to perform worse than low schizotypes on both the ToM and physical stories, and there was no statistical interaction between schizotypy and story type.

The second prediction here was based on C. Frith's (1992) hypothesis that the greatest ToM impairment in schizophrenia is associated with positive and negative 'behavioural signs', and that patients with paranoid symptoms and no behavioural signs have a less severe deficit. Frith further suggested that schizophrenic patients without behavioural or paranoid symptoms should have an intact ToM ability. Frith's research group carried out a number of studies with patients in which symptom subgroup analyses confirmed this hypothesis (Corcoran *et al.*, 1995; 1997; Corcoran & C. Frith, 1996; C. Frith & Corcoran, 1996; Pickup & C. Frith, in press), and it was

predicted that in the present study the poorest ToM scores would be shown by a subgroup of subjects scoring high on schizotypal traits analogous to behavioural signs (i.e. CD, IN and IA). It was expected that participants who scored high on positive symptom traits (the UE scale), but were not high on CD, IN and IA, would show a smaller ToM impairment than those in the behavioural signs group. Remaining participants, who scored low on all traits, were expected to show the best performance on the ToM tasks. These predictions were not supported, as there was no significant effect of group on story score. Inspection of the data revealed that the group scoring high on the UE scale showed a somewhat lower score on the ToM stories (but not physical stories) than the other groups, but this effect did not reach statistical significance.

The third prediction in the present study was based on those studies of ToM in schizophrenia in which the relation between symptomatology and ToM was explored using correlational rather than subgroup analyses (Doody *et al.*, 1998; Drury *et al.*, 1998; Langdon *et al.*, 1997; Mitchley *et al.*, 1998; Sarfati *et al.*, 1997a, b; 1999; Sarfati & Hardy-Baylé, 1999). Without exception, these studies found that impaired ToM was associated only with the 'behavioural signs' of schizophrenia rather than paranoid symptoms, and Pickup & C. Frith (in press) argued that the difference between these results and those of Frith's research group may reflect the different ways in which data were analysed. For example, in correlational analyses the strong association between behavioural signs and impaired ToM may mask the smaller contribution of paranoid symptomatology. Thus, any effect of paranoid symptoms

only appears when a paranoid subgroup without behavioural signs is compared with controls (as in Frith's studies).

On the basis of these arguments, it was predicted in the present study that correlation of schizotypy ratings with scores on the story tasks for the whole sample, would reveal an association between poorer ToM and higher scores for schizotypal traits analogous to the behavioural signs of schizophrenia (i.e. CD, IN, IA). Langdon & Coltheart (1999) performed such correlational analyses in their study of ToM and schizotypy, and in Experiment 1 of the study they found an association between poorer ToM and higher scores for negative schizotypal traits (consistent with the above discussion). However, Experiment 2 showed an association between poorer ToM and schizotypal traits similar to the 'unusual experiences' (UE) dimension in the present study. Langdon & Coltheart (1999) explained this inconsistency in terms of subjects' restricted range of scores for negative schizotypal traits in Experiment 2, and in the present study it was expected to find similar results to those of Langdon and Coltheart's Experiment 1, with an association between poorer ToM and higher scores on CD, IN or IA. This prediction was not supported, and the only correlation which approached significance was that between UE and ToM score, with higher scores on the UE scale being associated with poorer ToM. Results of hierarchical multiple regression analyses were consistent with this, showing that a composite of CD, IN and IA did not predict score on the ToM or physical stories, whereas addition of UE to the regression model significantly increased the amount of explained variance in ToM score, but not in physical stories score.

The following sections will examine possible explanations for the above results, and will explore why most of the predicted associations between schizotypy and ToM were not found:

1) Range of schizotypy scores

A possible explanation for the above findings is that participants showed a restricted range of scores on one or more of the O-LIFE dimensions, and that this low variance made it difficult to detect the predicted associations. Examination of the range of scores in Table 3.1 suggests this is unlikely. For example, the total schizotypy score in the present study ranged between 10 and 82, and the maximum possible total score on the O-LIFE (presumably found very rarely) is only 104. The range of total schizotypy was therefore probably not a factor in the failure to detect a difference in ToM between groups formed according to high and low total schizotypy score.

The present study was notable in that it was one of the few studies of schizotypy to date to use a screening questionnaire (the STA) to select participants, thereby ensuring a broad range of schizotypy within the sample. As discussed earlier, the STA primarily records schizotypal traits analogous to the positive symptoms of schizophrenia (Claridge & Broks, 1984), so it was likely to select subjects with a broad range of scores on the UE scale of the O-LIFE. This was indeed the case, the range of scores on UE being 0 - 27 (maximum possible = 30). Mason *et al.* (1995) found that UE correlated significantly with scores on the CD and IN scales of the O-LIFE, and accordingly the ranges on these scales in the present study were also high

[CD: 1 - 24 (max = 24); IN: 3 - 19 (max = 23)]. It is unlikely, therefore, that restricted ranges on CD or IN contributed to the failure to detect their predicted associations with ToM ability. The range of participants' scores on IA was smaller than that for the other O-LIFE scales [0 - 17 (max = 27)], but was probably still large enough to have enabled any association between ToM and IA to be detected, especially if the association was strong as predicted theoretically. It is possible that the range on this scale was smaller because of the great difficulty in finding participants who score very highly on IA. By definition, these people are introverted and unaccustomed to trying new experiences, so are probably unlikely to volunteer for a psychology study looking at social skills such as theory of mind.

2) Sample size

A second possible reason for the failure to detect the predicted associations between schizotypy and ToM, is that the sample size was too small and the statistical power of the study too low. This is unlikely, as the present sample size (N = 62) compared favourably with that in Langdon & Coltheart's (1999) study of schizotypy and ToM (N = 40 in Experiment 1; N = 28 in Experiment 2), where significant results were found. In addition, hierarchical multiple regression in the present study did show a significant association (between UE and ToM), so the sample size was clearly large enough to reveal this effect. Examination of other studies in the schizotypy literature in which different models of schizophrenia were investigated, shows that significant results were usually found with smaller samples than in the present study. For example Beech & Claridge (1987) found a significant difference between high and low

schizotypes in performance on a negative priming task with only 32 subjects, and Steel *et al.* (1996) found correlations between negative priming and the UE and CD components of the O-LIFE with only 36 participants.

It is worth noting that although the present sample size was adequate for regression analysis on the whole sample, and for comparison of high and low total schizotypy, the analysis which formed three schizotypy groups according to C. Frith's (1992) symptom-specific predictions, probably did have low statistical power because of insufficient subject numbers. Inspection of the data in this analysis showed somewhat poorer ToM performance by the group scoring high on the UE scale, but this effect failed to reach statistical significance (although the effect of UE was significant in regression on the whole sample). The high UE group comprised only 11 participants, whereas there were 18 and 33 in the other two groups, and it is likely that this small sample size reduced the power of the analysis. This suggests that future investigations of Frith's model within the schizotypy paradigm should use larger subject numbers if it is intended to divide participants into more than two schizotypy groups.

3) IQ effects

Verbal IQ is a possible confounding factor in all studies of ToM. For example, Happé (1995) noted that autistic children with a higher verbal IQ often performed better on ToM tasks than those with a lower IQ. Pickup & C. Frith (in press) used regression analysis to investigate predictors of ToM task performance in their sample of schizophrenic patients, and found that both ratings of behavioural signs and verbal IQ

scores were significant predictors. Langdon & Coltheart (1999) did not use a measure of general intelligence in their study of ToM and schizotypy, and although their use of control tasks meant that it was unlikely that IQ confounded the results, the design would have been improved by the use of an IQ measure. The present study was one of the few investigations of schizotypy to assess verbal IQ, and as IQ showed no correlation with subjects' performance on the story tasks, and did not moderate the effect of schizotypy on task performance, we can conclude that none of the current results were confounded by IQ effects.

As studies of schizophrenic patients often find that verbal IQ correlates with ToM task performance (e.g. Corcoran *et al.*, 1995; Pickup & C. Frith, in press), it is worth considering why such a correlation was not found here with normal adults assessed for schizotypy. Corcoran *et al.* (1995) found that IQ correlated with ToM only for their schizophrenic patients and not for normal controls, and they suggested this was because patients had impairments in ToM, so had to use IQ-dependent problem-solving skills to work out answers to the ToM questions. In contrast, normals were presumed to have intact ToM so did not need general problem-solving skills to answer the questions. As discussed in the Introduction, any ToM deficits in the present sample were expected to be small relative to those found in symptomatic schizophrenic patients. It was suggested that the ToM system would be intact in all of the normal individuals tested, and that any variation over the sample would be subtle and related to speed of 'on-line' processing and/or the accurate application of ToM in real-life situations. Results of the study showed that variation in ToM ability was indeed small, and by analogy with the above discussion it is likely that participants

rarely used IQ-dependent problem-solving skills to answer the ToM questions, hence the lack of association between IQ and task score.

4) Variations in executive function

As discussed earlier, this study used the Cognitive Estimates test (Shallice & Evans, 1978) to control for variation between participants in executive function, and we should consider now whether executive ability influenced the results in any way. Control for executive function was important as studies show that high schizotypy is often associated with poor performance on executive tests (e.g. Lenzenweger & Korfine, 1994; Obiols *et al.*, 1997; Raine *et al.*, 1992), and Russell (1998) argued that low scores on ToM tasks reflect a specific executive impairment in being 'captured' by, and responding to, salient but irrelevant information. In the present study, there was no evidence that participants' executive ability had any effect on the results. Scores on the Cognitive Estimates test did not moderate the relationship between schizotypy and performance on the stories tasks, and there was no correlation between executive function and story scores. These findings are consistent with the results of Langdon & Coltheart (1999), who found that, while schizotypy was clearly related to participants' scores on false belief stories, it was unrelated to scores on 'capture' stories, which were specifically designed to require inhibition of responses to salient, but irrelevant information.

Langdon & Coltheart's (1999) 'capture' stories were probably a better control for Russell's (1998) hypothesis than the Cognitive Estimates test, as they were very

similar to Langdon and Coltheart's false belief picture sequences, and differed only in their requirement that salient information be ignored. The Cognitive Estimates test was used here as it was short and easily administered in the available time, and was considered to control reasonably well for Russell's theory, as when generating responses on the task participants often have to inhibit the first answer which comes to mind in order to produce a reasoned estimate (Shallice & Evans, 1978). It is notable that no significant differences appeared in the present study between the scores of high and low schizotypes on the Cognitive Estimates test, and given Lenzenweger & Korfine's (1994) finding that high schizotypy is associated with poor performance on the Wisconsin Card Sorting Test (WCST; a recognised measure of the ability to inhibit irrelevant responses), it is possible that the Cognitive Estimates test was simply not sensitive enough to detect inhibitory difficulties in the present sample. It is recommended, therefore, that future studies of schizotypy and ToM use a test such as the WCST to control for executive function, given the demonstrated ability of this task to discriminate between high and low schizotypes.

5) Variations in reasoning ability

The present study controlled for variations over the sample in reasoning ability, and we should also consider any influence of this factor on the results. The physical stories served as a control both for the general reasoning component of the ToM stories, and for the suggestion by Currie (1996) and Harris (1995) that individuals perform poorly on ToM tasks because of difficulties imagining abstract or hypothetical states of affairs, rather than specific problems attributing mental states. Comparison of the task

performance of individuals grouped according to high (high-S) or low (low-S) total schizotypy, showed a non-significant tendency for the high-S group to score worse than the low-S group on both the ToM and physical stories. This may have reflected a tendency for high-S subjects in the present study to be poorer at reasoning or imagining abstract situations than low-S subjects. However, it is worth noting that Langdon & Coltheart (1999) found that their participants' total schizotypy score was unrelated to performance on the Tower of London planning task, so high-S subjects in that study did not show any evidence of reasoning problems or difficulties imagining hypothetical situations.

Another possible explanation for the tendency of high-S individuals in the present study to score more poorly on both sets of stories, was that they tended to pay less attention to the tasks than low-S subjects. This would be consistent with studies reviewed earlier (see section 1.2) showing that high schizotypes score more poorly than low schizotypes on tests of sustained attention (Chen *et al.*, 1997; 1998; Lenzenweger *et al.*, 1991), and show evidence of reduced selective attention on the negative priming paradigm (Beech & Claridge, 1987; Peters *et al.*, 1994; Steel *et al.*, 1996). As discussed earlier, it was predicted that a statistical interaction would appear in the present group analyses, so it would be expected that even if high-S subjects scored more poorly than low-S individuals on both sets of stories (reflecting, for example, poorer attention), they should score significantly worse than low-S subjects on the ToM stories (because of poorer ToM). This effect was not found, and further possible explanations for this will be explored shortly.

It is important to remember that hierarchical multiple regression of story task scores for the whole sample on the different schizotypy dimensions of the O-LIFE, showed a statistically significant association between UE and ToM score, while the association between UE and physical stories score was not significant. This suggests that the relation between UE and ToM was not an artefact of general reasoning difficulties, problems imagining abstract or hypothetical situations, or poor attention in participants with higher UE scores, but instead reflected a specific difficulty representing mental states. In showing an association between poorer ToM and higher scores on a dimension of schizotypy, this study provided further evidence in support of C. Frith's (1992) model of schizophrenia. However, on the basis of that model, it was predicted that the strongest associations would be between increasing scores for CD, IN and IA and poorer ToM, and that any associations between UE and ToM would be weaker. This was not found, and further possible explanations for the unexpected results of this study will now be discussed.

6) Discriminating power of the stories tasks

It is likely that part of the explanation for the different results of Langdon & Coltheart (1999) and the present study, lies in differences in discriminating power between the tasks used in the two studies. As discussed earlier, it was expected that variations in ToM over the present sample would be small, and related to speed of 'on-line' processing and/or the accurate application of ToM in real-life situations. It was considered important to use a sensitive ToM task which could detect small differences between participants, and it was hoped that Fletcher *et al.*'s (1995) stories would

serve this purpose. As a statistically significant association between ToM and UE scores was detected in the present study, the task clearly was discriminating enough to reveal an effect. However, examination of Langdon & Coltheart's (1999) data shows that these workers generally found statistically stronger effects than in the present study, and this may be because their task was more sensitive than the ToM and physical stories to small between-subjects differences in ToM ability.

For each condition of Langdon and Coltheart's task (i.e. mechanical, social-script, false belief and capture stories), subjects had to correctly sequence four sets of four cards to produce meaningful stories. Participants had to do the sequencing as fast as possible, and their first response sequence for each story was recorded. It is likely that the task was very sensitive to the speed and accuracy of subjects' 'on-line' understanding, as they had to process the situations in real time (as happens in everyday social interactions). Thus, any subtle impairments in understanding false belief scenarios relative to other scenarios could be revealed.

The ToM and physical stories in the present study also included a time measure, and this will be discussed in a later section. However, the test question for each story was read and answered by participants after timing had stopped, which meant that they could think about their response without the on-line time constraints of real-life social interactions. This probably meant that the story scores were less sensitive to small between-subjects variations in ability than Langdon & Coltheart's (1999) task. One way in which the task might be improved in future studies would be to depart from Fletcher *et al.*'s (1995) administration procedure and read each story once to subjects,

asking them to give an answer as quickly as possible after reading has finished. The time to answer the test question, and the accuracy of response, may then be more sensitive measures of ToM and reasoning ability than the dependent variables in the present study.

7) Questionnaires

Differences in discriminating power of tasks can explain why Langdon & Coltheart's (1999) study showed generally larger effect sizes than were found here, but we have still not explained why the present study failed to replicate those workers' findings of:

a) poorer ToM associated with higher scores for total schizotypy;

b) a relationship between poorer ToM and higher scores for schizotypal traits analogous to the negative behavioural signs of schizophrenia (Langdon & Coltheart, 1999, Experiment 1).

We have also not explained why no support was found in the present study for the prediction (based on C. Frith's (1992) model) that the strongest association between schizotypal traits and ToM would be found for the CD, IN or IA traits (i.e. those analogous to behavioural signs), and that any associations between ToM and UE (analogous to positive symptoms of schizophrenia) would be weaker. As discussed above, the one significant association found here was between poorer ToM and increasing scores on the UE dimension, and no other effects in the present data approached statistical significance.

We can go some way towards explaining the present results by considering differences between the questionnaires used here and in Langdon & Coltheart's (1999) study. The present study was the first investigation of ToM and schizotypy to use the O-LIFE questionnaire (Mason *et al.*, 1995), and this relatively new measure was chosen because it was considered to give a broad assessment of schizotypy, with about equal numbers of questions on each of the four dimensions. Langdon & Coltheart (1999) used the Schizotypal Personality Questionnaire (SPQ; Raine, 1991) which is based on DSM criteria for schizotypal personality disorder (e.g. DSM-IV; APA, 1994) and comprises three dimensions, namely 'cognitive-perceptual' (with subscales for ideas of reference, magical thinking and unusual perceptions), 'interpersonal' (with subscales for suspiciousness and paranoia, social anxiety, few friends and constricted affect), and 'disorganised' (with subscales for odd speech and odd behaviour).

As noted by Claridge *et al.* (1997), the SPQ has a strong focus on schizotypal traits analogous to the positive symptoms of schizophrenia. Thus, the three cognitive-perceptual subscales and the suspiciousness and paranoia subscale are all similar to parts of the UE scale of the O-LIFE. Only two of the nine SPQ subscales (few friends and constricted affect) are similar to the IA scale of the O-LIFE, and only three SPQ subscales (social anxiety, odd speech and odd behaviour) map onto the CD and IN scales of the O-LIFE. This means that about half of the 'total schizotypy' measured by the SPQ is similar to the UE dimension of the O-LIFE (whereas UE makes up only about 25% of the total schizotypy assessed by the O-LIFE). UE was the only one of the four O-LIFE dimensions in the present study to show a significant association

with ToM ability, and it is possible that Langdon & Coltheart's (1999) finding of an association between poorer ToM and high total schizotypy reflected the large weighting of the total SPQ score towards UE-type schizotypal traits. This analysis suggests that the results of Langdon and Coltheart's work and the present study are consistent with one another in finding an association between ToM and UE-type schizotypal traits.

This argument is supported to some extent by Langdon & Coltheart's (1999) analyses of the relative associations between ToM ability and the different dimensions of the SPQ. For example, in Experiment 2 of their study, these workers found that poorer ToM was associated with high scores on the cognitive-perceptual dimension of the SPQ (analogous to the UE scale of the O-LIFE). As discussed earlier, Experiment 1 of Langdon and Coltheart's study showed that poorer ToM was related to higher scores on the interpersonal dimension of the SPQ, and given that part of this dimension consists of UE-type items assessing paranoia and suspiciousness, the results of Experiment 1 may again be consistent with the present finding of an association between poor ToM and high UE scores. However, Langdon & Coltheart (1999) interpreted the results of their Experiment 1 as showing a relationship between poor ToM and negative schizotypal traits such as few friends and flat affect, which suggests that these components of the interpersonal dimension made a substantial contribution to the variance in the data. In summary, therefore, it is possible to draw some similarities between the present results and those of Langdon & Coltheart (1999) by considering the importance of UE-type schizotypal traits in both studies. However, the fact remains that Langdon and Coltheart also found an association

between poor ToM and negative schizotypal traits which, while consistent with C. Frith's (1992) model of schizophrenia, was not found in the present study.

There are two possible reasons for the absence in the present data of any statistical association between ToM ability and schizotypal traits analogous to the behavioural signs of schizophrenia. The first possibility is that there really was no association, in which case no evidence was found to support C. Frith's (1992) hypothesis that ToM impairments are associated with the behavioural signs of schizophrenia. The second possibility is that an association was present, but that it was not detected, perhaps because of poor sensitivity of the O-LIFE questionnaire. It is notable that the interpersonal dimension of the SPQ used by Langdon & Coltheart (1999), focused exclusively on the negative schizotypal traits of few friends and flat affect, and asked no questions about anhedonic traits. In contrast, the introvertive anhedonia (IA) scale of the O-LIFE asked about anhedonia as well as having questions about the traits tapped by the SPQ. It is possible that in normal individuals poor performance on ToM tasks is specifically associated with having few friends and flat affect, and has no association with anhedonic traits. This would mean that the total IA score would have little association with ToM ability (as found here), whereas the SPQ 'interpersonal' score would be more strongly related to ToM (as found by Langdon & Coltheart, 1999). This is clearly a speculative post hoc explanation, but it is consistent with the fact that the ToM tasks used here, and in Langdon and Coltheart's study, all required understanding of other people's mental states, a skill which is more clearly relevant to making friends and interacting affectively with people, than to the particular hedonic experiences sampled by the O-LIFE, such as trying new foods or finding the bright

lights of a city exciting. This argument predicts that if the present data were re-analysed, an association should appear between ToM ability and scores on the particular IA questions related to affect or friendships.

In this section, subtle differences between the O-LIFE and SPQ have been used to account for some of the discrepancies between the present results and those of Langdon & Coltheart (1999). A useful way of testing the hypotheses advanced would be to repeat the study, giving both the O-LIFE and SPQ to all participants. If questionnaire differences were indeed important in determining the results, then we would expect to broadly replicate both the present study and that of Langdon & Coltheart (1999) within the same sample.

8) The difference between schizotypy and schizophrenia

In drawing similarities between the present results and those of Langdon & Coltheart (1999), the above discussion highlighted the association between UE-type schizotypal traits and poorer ToM in normal individuals. This emphasis is clearly different from that in C. Frith's (1992) model of schizophrenia, which stressed the strong association between ToM impairments and the presence of behavioural signs in patients. One possibility is that the strong association between ToM and behavioural signs only appears in patient studies (e.g. Corcoran *et al.*, 1995; 1997; Corcoran & C. Frith, 1996; Doody *et al.*, 1998; Drury *et al.*, 1998; C. Frith & Corcoran, 1996; Langdon *et al.*, 1997; Mitchley *et al.*, 1998; Pickup & C. Frith, in press; Sarfati *et al.*, 1997a, b;

1999; Sarfati & Hardy-Baylé, 1999), and that the main effect in studies of schizotypy in normals is the association between 'unusual experiences' and poorer ToM.

One reason for this may be that the main index of psychosis-proneness in normal individuals is the reporting of UE-type traits, and that schizotypal traits analogous to behavioural signs are only reliably associated with psychosis-proneness in a subgroup of normal individuals. This is similar to a model of schizophrenia advanced by Murray *et al.* (1992), which noted that most schizophrenic illnesses start with an acute psychotic episode (typically involving hallucinations and delusions), with the patient having generally good pre-morbid functioning. However, a subgroup of people are thought to have a 'neurodevelopmental' form of schizophrenia, which manifests early in adolescence with mild negative behavioural signs, and then deteriorates into severe psychotic illness. In the light of this argument, it is notable that most schizotypy studies reviewed in section 1.2 of the Introduction found that cognitive deficits in normal individuals were most strongly associated with UE-type schizotypal traits (e.g. Beech & Claridge, 1987; Lenzenweger & Korfine, 1994; Peters *et al.*, 1994; Steel *et al.*, 1996). If correct, this focus on the importance of UE-type traits as an index of psychosis-proneness in normal individuals, suggests that the schizotypy paradigm may be most useful for investigating models of schizophrenia which account for positive symptoms such as delusions and hallucinations, rather than behavioural signs.

Story reading times

Story reading times will only be reviewed briefly here as they add little to the results from the story tasks discussed above. Participants were timed while reading the ToM and physical stories, and on the basis of C. Frith's (1992) model it was predicted that high schizotypy would be associated with poorer ToM, which may manifest as longer reading times on the ToM stories than on the physical stories. This prediction was not supported: there was no association between total schizotypy and story reading time, nor between the UE, CD or IA schizotypy dimensions of the O-LIFE and reading time. In contrast, Langdon & Coltheart (1999; Experiment 1) found some evidence that high schizotypes took longer than low schizotypes to correctly sequence false-belief stories relative to other story types.

By analogy with the earlier discussion of story scores, the most likely reason for the null results in the present study was the poor sensitivity of the reading time measure to small between-subjects differences in ToM. Fletcher *et al.*'s (1995) administration procedure for the stories, which was used here, allowed participants to read the stories for as long as they wished before answering the test question. This meant that, as well as reflecting subjects' ability to process the story information 'on-line', the reading time data were affected by participants' thoroughness and willingness to perform well on the task. It has already been suggested that a better administration procedure in future studies would involve reading each story once to subjects, then recording the time taken to answer the test question and the accuracy of the response. Time to respond may be a more sensitive index of participants' ability to process the

story on-line, and may be more likely to reveal small between-subjects differences in ToM than the reading time measure in the present study.

In their pilot study of 60 normal volunteers, Fletcher *et al.* (1995) found that the physical stories were read significantly more slowly than the ToM stories. This result was replicated here, and the present data clearly showed that the extra time taken by participants to read the physical stories was a function of verbal IQ. One unexpected finding was the significant negative correlation between participants' score on the IN (impulsive non-conformity) subscale of the O-LIFE and reading time for the physical stories. As IN is an index of impulsivity, this relationship may reflect the relative lack of thoroughness or concern to perform well associated with high IN scores, which manifested on the task as rapid reading relative to other participants.

Use of mental state language on the ToM stories

On the basis of C. Frith's (1992) model, it was predicted that high schizotypy would be associated with less use of mental state terms (e.g. 'thinks', 'knows') in participants' responses to the ToM stories. This prediction was not supported, either when subjects were grouped according to high or low total schizotypy, or when mental state score was correlated with the different schizotypy dimensions of the O-LIFE. Langdon & Coltheart (1999) did not investigate the use of mental state language in their study, so the present investigation was the first to explore the relationship between schizotypy and use of mental state terms. Most studies of ToM in schizophrenia have not looked at the use of mental state language by patients,

although one exception to this (Pickup & C. Frith, in press) did find that patients with behavioural signs used significantly less mental state terms than patients in remission. The null result in the present study may be related to the small variation in ToM ability over the sample of normal individuals. As discussed earlier, all participants in the present study probably had intact ToM, and differed only in their ability to use ToM on-line in real-life situations. It may be that quite large ToM impairments (as found in schizophrenic patients with behavioural signs) are necessary before any noticeable reduction in the use of mental state language occurs.

4.3 PERFORMANCE ON THE EMBEDDED FIGURES TEST (EFT)

This part of the present study was based on research in the autism literature which suggests that autistic people focus on detail rather than gestalt. U. Frith (1989, p. 101) argued that autism is characterised by a cognitive style of 'weak central coherence' (WCC), wherein the priority given by normal individuals to the understanding of meaning is replaced by an emphasis on parts rather than the 'whole picture'. This model is not considered as a competitor to the ToM hypothesis, but rather as a useful additional theory which can account for some of the non-social features of autism (e.g. good rote memory and unusual interests) not addressed by the ToM model. As discussed in section 1.4 of the Introduction, a number of empirical studies of autistic people have supported the model, using tasks involving the reading of homographs in context (U. Frith & Snowling, 1983; Happé, 1997; Jolliffe & Baron-Cohen, 1999), the construction of Block Design patterns (Shah & U. Frith, 1993), the size judgement of parts of visual illusion stimuli (Happé, 1996), and the

finding of hidden objects within embedded figures stimuli (Jolliffe & Baron-Cohen, 1997; Shah & U. Frith, 1983).

By analogy with C. Frith & U. Frith's (1991) extension of the ToM account of autism into schizophrenia, Pickup (1997) noted that some clinical descriptions of schizophrenic patients also mention a focus on detail rather than gestalt. Pickup (1997) reviewed a number of studies in the schizophrenia literature which, despite being designed to investigate quite different cognitive models of schizophrenia, provide some evidence for a WCC cognitive style in symptomatic schizophrenic patients. These studies were discussed in section 1.4 of the Introduction, and involved the choice of correct word meaning to fit sentence contexts (Done & C. Frith, 1984; Naficy & Willerman, 1980), performance on Block Design tasks (Green & Walker, 1985; Robertson & Taylor, 1985), and size judgement of visual illusion stimuli (Capozzoli & Marsh, 1994). As discussed by Pickup (1997), these studies found that both the behavioural signs and positive symptoms of schizophrenia were associated with weak central coherence on the tasks.

By analogy with Jolliffe & Baron-Cohen (1997) and Shah & U. Frith (1983) in the autism literature, Pickup (1997) investigated the performance of schizophrenic patients on a new embedded figures test (EFT) designed for adults. Pickup found some limited evidence for a WCC style in his symptomatic patients, as individuals with either positive symptoms or behavioural signs found as many hidden objects as controls, while remitted (symptom-free) patients found significantly less objects than controls. Pickup noted that all of the schizophrenic patients in his study were taking

anti-psychotic medication, and he suggested that their task performance may have been compromised by non-specific effects associated with a present or past psychiatric illness, such as the adverse effects of medication on psychomotor speed. Pickup argued that with adequate control for these effects, symptomatic schizophrenic patients may show clear evidence of weak central coherence on the EFT by performing faster and finding more objects (greater accuracy) than remitted patients or controls.

We have seen throughout this thesis that the schizotypy paradigm provides a useful means of investigating models of schizophrenia without the potentially confounding effects of non-specific factors associated with psychiatric illness. In the present study, therefore, the performance of normal individuals assessed for schizotypy was investigated on Pickup's (1997) embedded figures test. It was predicted that high schizotypes would perform faster and more accurately on the task than low schizotypes, and that good performance would be particularly associated with schizotypal traits analogous to autistic features (i.e. the IA, IN and CD dimensions of the O-LIFE). However, given the evidence discussed above that some of the positive symptoms of schizophrenia may also be associated with weak central coherence, it was expected that good task performance in the present study may also be related to high scores on the UE dimension of the O-LIFE.

No support for these predictions was found in the study. There were no differences in accuracy or speed of performance on the EFT between participants divided into high and low total schizotypy groups. Similarly, none of the O-LIFE dimensions were

significantly correlated with accuracy or speed of performance on the task. The only evidence of any association between schizotypy and task performance was found in the negative correlation between search time and score on the IA scale of the O-LIFE. However, even without correction for multiple comparisons this relationship only approached statistical significance at the one-tailed level. The largest correlation in the study was between spatial IQ and accuracy of performance (greater accuracy associated with higher IQ), and this approached significance with correction for multiple comparisons.

Weak central coherence and schizophrenia

These results do not support Pickup's (1997) suggestion that the weak central coherence account of autism can be extended into schizophrenia. While the present study had an adequate sample size, range of schizotypy and questionnaire sensitivity to detect a significant association between UE and ToM ability, no associations were found between schizotypy and weak central coherence. The null result is unlikely to reflect poor discriminating power of the EFT, as the task was able to discriminate between controls and remitted schizophrenic patients in Pickup's (1997) study. In addition, it could discriminate between participants with high and low spatial IQ in the present study. The most likely explanation of the present findings, therefore, is that any relation between schizotypy and WCC in the present sample was very weak or non-existent.

This finding calls into question Pickup's (1997) argument that the results of several studies in the schizophrenia literature suggest weak central coherence in the disorder. As these studies were not specifically designed to test the WCC model, it is certainly possible that the results did reflect cognitive deficits in patients which were unrelated to WCC. However, Naficy & Willerman's (1980) sentence-completion study (discussed in section 1.4) and Capozzoli & Marsh's (1994) study of visual illusion perception in schizophrenia, are persuasive and suggest that some patients do tend to focus on detail rather than gestalt. Further work is therefore needed in which the WCC model is investigated with schizophrenic patients. One useful study would involve administration of Happé's (1996) illusions task to patients, to explore the relationship between symptoms and task performance. This task was able to reveal a WCC-style in autism, so if schizophrenic patients also show weak central coherence, they should perform similarly on the task to autistic individuals.

Some of the studies reviewed by Pickup (1997) found only limited evidence of a WCC style in schizophrenia, and one possibility is that the effect, if present in patients, is weak and difficult to detect. For example, Green & Walker (1985) showed that schizophrenic patients performed significantly worse than controls on all tasks administered, except for Block Design and a test of motor control (where they performed similarly to controls). Thus, if the relative task superiority on Block Design reflected the operation of WCC, the effect was clearly weak as patients did not perform better than controls on the task. Similarly, Pickup (1997) found that symptomatic schizophrenic patients performed as well as controls on the EFT, and although symptom-free patients scored worse than controls, the predicted association

between symptomatology and superior task performance was not found. A weak relationship between symptomatology and WCC in schizophrenia would be consistent with the failure of the present study to detect any effect in normal individuals, as the schizotypy paradigm assumes that effect sizes will be smaller in normals than in schizophrenic patients.

Weak central coherence and autism

As a number of carefully-designed studies have clearly revealed weak central coherence in autism (e.g. U. Frith & Snowling, 1983; Happé, 1996; 1997; Jolliffe & Baron-Cohen, 1997; 1999; Shah & U. Frith, 1983; 1993), it is highly likely that the effect in autistic individuals is stronger than any WCC effect in schizophrenia. In this context, it is interesting that the largest correlation in the present study was between search time and score on the IA dimension of the O-LIFE, with high IA being associated with faster search time. Although the correlation did not reach statistical significance, it is notable that IA is the dimension of schizotypy with greatest similarity to the classic autistic presentation of social withdrawal, flat affect and few interests. It is possible, therefore, that any empirical association between IA and performance on the EFT reflects the weak central coherence effect in autism.

4.4 SUMMARY AND CLINICAL IMPLICATIONS OF THE WORK

This study investigated two separate psychological models of schizophrenia using the schizotypy paradigm. In this final section, the results of both parts of the study will be summarised and clinical implications addressed.

Schizotypy and Theory of Mind (ToM): Summary

On the basis of C. Frith's (1992) cognitive neuropsychological model of schizophrenia, it was predicted that high scores for total schizotypy in normal individuals would be associated with subtle impairments on tests of ToM. It was further expected that poorer ToM would be related to high scores for schizotypal traits analogous to the 'behavioural signs' and positive symptoms of schizophrenia. Only one of the predictions was supported by the study: the 'unusual experiences' (UE) dimension of schizotypy (analogous to positive symptoms) was associated with poorer ToM in normal individuals. However, there were no associations between ToM ability and total schizotypy, nor between ToM and traits analogous to behavioural features (CD, IA and IN). The use of appropriate control tasks ruled out competing explanations of the data in terms of between-subjects differences in verbal IQ, executive function or reasoning ability, so it was concluded that the association between UE and ToM did reflect subtle difficulties in mental state representation in high-UE normal individuals.

Discussion focused on the difference between the present results and those of Langdon & Coltheart (1999), who found that poorer ToM in normals was associated with high total schizotypy, and with high scores for schizotypal traits analogous to the behavioural signs and positive symptoms of schizophrenia. It was noted that Langdon and Coltheart's schizotypy questionnaire (the SPQ; Raine, 1991) has a strong focus on UE-type schizotypal traits, so their finding of poorer ToM being associated with high total schizotypy was considered to be consistent with the present results. Differences were also noted between the SPQ and O-LIFE in terms of sensitivity to particular behavioural signs-type traits. The SPQ focuses exclusively on absence of friends and flat affect, features which intuitively may be related to ToM ability. In contrast, the O-LIFE asks questions about additional traits (e.g. anhedonia) which may not be related to ToM. It was concluded, therefore, that while the present study found further evidence to support C. Frith's (1992) model relating ToM to positive psychotic symptoms, the absence of an association with behavioural signs-type features may have been related to the sensitivity of the questionnaire used. A further study was suggested involving administration of both the SPQ and O-LIFE in order to test this possibility.

Schizotypy and ToM: Clinical Implications

The present study has replicated the finding that ToM ability varies across the normal population (Langdon & Coltheart, 1999). The variation is small, and probably related to speed of processing or the ability to apply ToM accurately in real-life situations. However, we may hypothesise that differences in ToM contribute to the variation in

social competence across normal individuals. A future study could investigate this directly by examining the relation in normals between performance on standard tests of ToM and other measures of social competence (e.g. ratings of videotaped social interactions).

The present study has provided further evidence to support C. Frith's (1992) cognitive neuropsychological model of schizophrenia, in particular Frith's suggestion that positive psychotic symptoms are associated with impaired ToM. To date, the ToM concept has rarely been used clinically with schizophrenic patients. However its use has increased in learning disability services, particularly with autistic clients, where ToM can be used to inform assessment, formulation and intervention (e.g. Hadwin *et al.*, 1997). Extrapolation from this area suggests that with psychotic patients, ToM may have clinical utility in the following ways:

Assessment

Administration of standard ToM tasks could provide information on the severity of ToM impairments in schizophrenic patients. Thus, patients' performance on first-order and (more difficult) second-order tasks indicates the degree of impairment in mental state representation. As reduced ToM ability has been shown to be associated with higher ratings of symptomatology (e.g. Langdon *et al.*, 1997), the task data could be used to inform clinical ratings of symptom severity.

Formulation

A conceptualisation of schizophrenia in terms of impaired ToM may enable the clinician to more accurately empathise with patients and understand their 'world view'. For example, a patient's delusion of reference that a person on a train had communicated with him by raising her eyebrows, may be understood in terms of him mistakenly attributing communicative intent to someone who happened to be frowning to herself. This kind of understanding could help dispel the commonly heard assertion that patients are 'just mad' and reporting experiences which have no basis in reality.

Interventions

ToM formulations could directly inform patient care plans, e.g. in inpatient settings. For example, if it is felt that a patient has ToM impairments, he or she might be expected to have difficulty understanding figurative language such as irony or jokes. Care staff could then be instructed to communicate in a straight forward, concrete manner with the patient. Similarly, a patient who has difficulty predicting others' intentions may become anxious in unstructured or unpredictable situations. This may mean that part of the care plan involves a structured ward routine so that the patient feels safer, knowing that they and others will be doing particular things at certain times of the day.

It is possible that teaching and discussion of ToM concepts could be incorporated into cognitive-behaviour therapy (CBT) programs for people with psychosis (e.g. Fowler *et al.*, 1998). Thus, a psychoeducational approach could inform patients of the ToM model, and discussion could then focus on evaluation of evidence for and against the assertion that particular people had certain mental states. Hadwin *et al.* (1997) attempted to teach mental state concepts to autistic individuals, but had only limited success (finding that participants could learn how to pass particular ToM tasks, but then did not generalise this skill to novel situations). This may be because ToM ability relies upon intact neuronal structures or neurochemical pathways (e.g. Fletcher *et al.*, 1995), so cannot be learnt if the neural substrate is absent. This argument suggests that ToM-focused CBT work with psychotic patients may similarly have limited success. However, the approach may be helpful for patients who are receiving antipsychotic medication, as it is thought that levels of neurotransmitters such as dopamine are closer to normal levels in such individuals (see C. Frith, 1992, for a review).

Schizotypy and 'Weak Central Coherence' (WCC): Summary

Pickup (1997) extended the 'weak central coherence' (WCC) account of autism into schizophrenia, and suggested that individuals with a psychotic illness (especially those with behavioural signs analogous to autistic features) may demonstrate a cognitive style characterised by focus on detail rather than gestalt. On this basis, it was predicted in the present study that high schizotypy (particularly scores on the CD, IA and IN dimensions of the O-LIFE) would be associated with good performance on an

embedded figures test (EFT). No support for this prediction was found, as there were no associations between schizotypal traits and accuracy or speed of EFT performance.

Schizotypy and WCC: Clinical Implications

This finding does not support Pickup's (1997) suggestion that the WCC account of autism can be extended into schizophrenia. Pickup (1997) found weak evidence for a WCC cognitive style in his study of schizophrenic patients, but the effect sizes in that study were smaller than in his study of ToM and schizophrenia (Pickup & C. Frith, in press). One possibility, therefore, is that any associations between psychotic symptoms and WCC are smaller than associations between symptomatology and ToM, so that when WCC effects are investigated in normal individuals assessed for schizotypy, they become very difficult to detect. Overall, this analysis suggests that WCC effects make, at best, only a small contribution to the psychopathology of schizophrenia, and that variations in ToM ability are more strongly related to symptoms. Thus, while further theoretical work may usefully explore WCC effects in schizophrenic patients, it is not yet possible to say that the WCC model can contribute significantly to the assessment or formulation of psychosis.

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APPENDIX 1: STA AND O-LIFE QUESTIONNAIRES

STA SCREENING QUESTIONNAIRE - CONFIDENTIAL

Age ..... Sex M F (please circle one)

Please answer each question by circling either Y or N:

Do you believe in telepathy?
Y N

Do you often feel that other people have it in for you?
Y N

When in the dark do you often see shapes and forms, even though there's nothing there? Y N

If you say you will do something, do you always keep your promise no matter how inconvenient it might be?
Y N

Does your own voice ever seem distant, faraway?
Y N

Does it often happen that almost every thought immediately and automatically suggests an enormous number of ideas?
Y N

Do you ever become oversensitive to light or noise?
Y N

Were you ever greedy by helping yourself to more than your share of anything?
Y N

Do you often have vivid dreams that disturb your sleep?
Y N

When you are worried or anxious do you have trouble with your bowels?
Y N

Have you ever felt when you looked in a mirror that your face seemed different?
Y N

Have you ever blamed someone for doing something you knew was really your fault?
Y N

Do you feel it is safer to trust nobody?
Y N

Do things sometimes feel as if they were not real?
Y N

Do you feel lonely most of the time even when you're with people?
Y N

Are *all* your habits good and desirable ones?
Y N

Do everyday things sometimes seem unusually large or small?
Y N

Are you often bothered by the feeling that people are watching you?
Y N

Do you feel that you cannot get 'close' to other people?
Y N

Have you ever taken anything (even a pin or button) that belonged to someone else?
Y N

Do you dread going into a room by yourself where other people have already gathered and are talking?
Y N

Does your sense of smell sometimes become unusually strong?
Y N

Are you sometimes sure that other people can tell what you are thinking?
Y N

Have you ever broken or lost something belonging to someone else?
Y N

Have you ever had the sensation of your body or part of it changing shape?
Y N

Do you ever feel sure that something is about to happen even though there doesn't seem to be any reason for your thinking that?
Y N

Do you ever suddenly feel distracted by distant sounds that you are not normally aware of? Y N

Have you ever said anything bad or nasty about anyone?
Y N

Do you ever have a sense of vague danger or sudden dread for reasons that you do not understand?
Y N

Have you ever thought you heard people talking only to discover that it was in fact some nondescript noise?

Y N

Do your thoughts ever stop suddenly causing you to interrupt what you're saying?

Y N

As a child were you ever cheeky to your parents?

Y N

Do you feel that you have to be on your guard even with your friends?

Y N

Do you ever feel that your thoughts don't belong to you?

Y N

When in a crowded room do you often have difficulty in following a conversation?

Y N

Have you ever cheated at a game?

Y N

Do you sometimes feel that your accidents are caused by mysterious forces?

Y N

Do you feel at times that people are talking about you?

Y N

Do you believe that dreams can come true?

Y N

Have you ever taken advantage of someone?

Y N

Do you ever feel that your speech is difficult to understand because the words are all mixed up and don't make sense?

Y N

Are your thoughts sometimes so strong that you can almost hear them?

Y N

When coming into a new situation, have you ever felt strongly that it was a repeat of something that has happened before?

Y N

Do you always practice what you preach?

Y N

Have you ever felt that you were communicating with another person telepathically?

Y N

Are you easily distracted from work by daydreams?

Y N

Are you very hurt by criticism?

Y N

Do you sometimes put off until tomorrow what you ought to do today?

Y N

Do you ever get nervous when someone is walking behind you?

Y N

CONFIDENTIAL

OXFORD-LIVERPOOL INVENTORY OF FEELINGS AND EXPERIENCES

Number:

Please complete the following questions. All answers that you give are anonymous and identified only by the above number. They will be treated in strict confidence. You are free to leave the study at any point if you would prefer not to answer any of these questions. You do not have to give any reason if you decide to leave the study.

Age .....

Sex M F (please circle one)

Are you currently suffering from a diagnosed mental health problem such as major depression or anxiety, or schizophrenia, which has caused you to seek medical advice?

Y N (please circle one)

PLEASE TURN OVER

Please answer each question by circling either Y or N

Do you often have a day when indoor lights seem so bright that they bother your eyes? Y N

Do you frequently have difficulty in starting to do things?
Y N

Do you enjoy many different kinds of play and recreation?
Y N

Do you consider yourself to be pretty much an average kind of person?
Y N

Are the sounds you hear in your daydreams usually clear and distinct?
Y N

Do you often hesitate when you are going to say something in a group of people that you know more or less?
Y N

Have you had very little fun from physical activities like walking, swimming or sports?
Y N

Do you often overindulge in alcohol or food?
Y N

Are your thoughts sometimes as real as actual events in your life?
Y N

Do you often worry about things you should not have done or said?
Y N

Has dancing, or the idea of it, always seemed dull to you?
Y N

When with groups of people, do you usually prefer to let someone else be the centre of attention?
Y N

Does it often happen that nearly every thought immediately and automatically suggests an enormous number of ideas?
Y N

When in a crowded room, do you often have difficulty in following a conversation?
Y N

Is trying new foods something you have always enjoyed?
Y N

When you catch a train, do you often arrive at the last minute?
Y N

Are your thoughts sometimes so strong that you can almost hear them?
Y N

No matter how hard you try to concentrate, do unrelated thoughts always creep into your mind? Y N

Are there very few things you have ever really enjoyed doing?
Y N

Do you often change between intense liking and disliking of the same person?
Y N

Do you think you could learn to read others' minds if you wanted to?
Y N

Are you easily hurt when people find fault with you or the work you do?
Y N

Are you much too independent to really get involved with other people?
Y N

Have you ever cheated at a game?
Y N

Have you felt that you have special, almost magical powers?
Y N

Do you easily lose courage when you are criticized or failing in something?
Y N

Do you think having close friends is not as important as some people say?
Y N

Do you at times have an urge to do something harmful or shocking?
Y N

Do ideas and insights sometimes come to you so fast that you cannot express them all? Y N

Do you seem to be a person whose mood goes up and down easily?
Y N

Are you rather lively?
Y N

Are you usually in an average sort of mood, not too high and not too low?
Y N

Can some people make you aware of them just by thinking about you?
Y N

Are you sometimes so nervous that you are 'blocked'?
Y N

Does it often feel good to massage your muscles when they are tired or sore?
Y N

Would you take drugs which may have strange or dangerous effects?
Y N

Does a passing thought sometimes seem so real that it frightens you?
Y N

Do you find it difficult to keep interested in the same thing for a long time?
Y N

Do you like mixing with people?
Y N

Do you stop to think things over before doing anything?
Y N

Does your voice ever seem distant, faraway?
Y N

Do you dread going into a room by yourself where other people have already gathered and are talking?
Y N

On seeing a soft, thick carpet have you sometimes had the impulse to take off your shoes and walk barefoot on it?
Y N

Have you ever blamed someone for doing something you know was really your fault?
Y N

Do you sometimes feel that your accidents are caused by mysterious forces?
Y N

Do you often have difficulties in controlling your thoughts when you are thinking?
Y N

Are people usually better off if they stay aloof from emotional involvements with most others? Y N

Would being in debt worry you?
Y N

Do people in your daydreams seem so true to life that you sometimes think they are?
Y N

Do you often feel that there is no purpose to life?
Y N

Can just being with friends make you feel really good?
Y N

Do you think people spend too much time safeguarding their future with savings and insurance? Y N

Is your hearing sometimes so sensitive that ordinary sounds become uncomfortable?
Y N

Do you worry about awful things that might happen?
Y N

Have you often felt uncomfortable when your friends touch you?
Y N

Do you ever have the urge to break or smash things?
Y N

Have you felt that you might cause something to happen just by thinking too much about it? Y N

Are you easily distracted from work by daydreams?
Y N

When things are bothering you, do you like to talk to other people about it?
Y N

Have you ever felt the urge to injure yourself?
Y N

Are you so good at controlling others that it sometimes scares you?
Y N

Are you easily confused if too much happens at the same time?
Y N

Do you have many friends?
Y N

Would it make you nervous to play the clown in front of other people?
Y N

Do you ever have a sense of vague danger or sudden dread for reasons that you do not understand?
Y N

Do you worry too long after an embarrassing experience?
Y N

Do you prefer watching television to going out with other people?
Y N

Have you ever taken advantage of someone?
Y N

Have you sometimes had the feeling of gaining or losing energy when certain people look at you or touch you?
Y N

Do you often feel lonely?
Y N

Is it true that your relationships with other people never get very intense?
Y N

Would you like other people to be afraid of you?
Y N

Have you ever thought you heard people talking only to discover that it was in fact some nondescript noise?
Y N

Do you often experience an overwhelming sense of emptiness?
Y N

Do you love having your back massaged?
Y N

Do you often have an urge to hit someone?
Y N

Have you occasionally felt as though your body did not exist?
Y N

Do you often feel 'fed up'?
Y N

Is it fun to sing with other people?
Y N

Do people who drive carefully annoy you?
Y N

On occasions, have you seen a person's face in front of you when no one was in fact there? Y N

Would you call yourself a nervous person?
Y N

Do people who try to get to know you better usually give up after a while?
Y N

Do you sometimes talk about things you know nothing about?
Y N

Have you wondered whether the spirits of the dead can influence the living?
Y N

Is it hard for you to make decisions?
Y N

Can you usually let yourself go and enjoy yourself at a lively party?
Y N

Do you often feel like doing the opposite of what other people suggest, even though you know they are right?
Y N

Have you felt as though your head or limbs were somehow not your own?
Y N

Do you ever feel that your speech is difficult to understand because the words are all mixed up and don't make sense?
Y N

Are the bright lights of a city exciting to look at?
Y N

Do you often feel the impulse to spend money which you know you can't afford?
Y N

Now and then when you look in the mirror, does your face seem quite different than usual? Y N

Are you easily distracted when you read or talk to someone?
Y N

Do you usually have very little desire to buy new kinds of foods?
Y N

Do you ever feel that your thoughts don't belong to you?
Y N

Do you like going out a lot?
Y N

Do you ever suddenly feel distracted by distant sounds that you are not normally aware of? Y N

Do you feel very close to your friends?
Y N

When in the dark, do you often see shapes and forms even though there's nothing there? Y N

Do you feel that making new friends isn't worth the energy it takes?
Y N

Have you sometimes sensed an evil presence around you, although you could not see it? Y N

Does your sense of smell sometimes become unusually strong?
Y N

Do you ever feel sure that something is about to happen, even though there does not seem to be any reason for you thinking that?
Y N

APPENDIX 2: ToM AND PHYSICAL STORIES

STORIES TASK

There are 2 conditions in this test, consisting of two sorts of materials;

ToM - stories to do with mental states (numbered 1 - 8)

Physical - stories to do with physical behaviour (numbered 9 - 16)

There are 8 examples of each of these 2 sorts. All 8 passages of one type are given together, but the order of the 2 conditions is counterbalanced (i.e. subject 1 gets ToM then Physical; subject 2 gets Physical then ToM, etc.).

Each passage is followed by a question, which appears on a separate page. Subjects are given a practice item first, and instructed, in words to this effect;

"On each page you will find a short story to read. After you've read and understood the story, I want you to turn the page. There is a question after each story, and I'd like you to tell me the answer to this question. I don't want you to look back at the story, so make sure you've understood it before turning over for the question."

The practice story will be given before the first Physical or ToM story is given. For each story, the subject should read the passage, and then answer the question. Time taken to read the story, i.e. time from story presentation until subject turns the page, will be recorded.

ToM stories

1. Simon is a big liar. Simon's brother Jim knows this, he knows that Simon never tells the truth! Now yesterday Simon stole Jim's ping-pong bat, and Jim knows Simon has hidden it somewhere, though he can't find it. He's very cross. So he finds Simon and he says, "Where is my ping-pong bat? You must have hidden it either in the cupboard or under your bed, because I've looked everywhere else. Where is it, in the cupboard or under your bed?" Simon tells him the bat is under his bed.

Q: Why will Jim look in the cupboard for the bat?

2. During the war, the Red army captures a member of the Blue army. They want him to tell them where his army's tanks are; they know they are either by the sea or in the mountains. They know that the prisoner will not want to tell them, he will want to save his army, and so he will certainly lie to them. The prisoner is very brave and very clever, he will not let them find his tanks. The tanks are really in the mountains. Now when the other side ask him where his tanks are, he says, "They are in the mountains".

Q: Why did the prisoner say that?

3. Brian is always hungry. Today at school it is his favorite meal - sausages and beans. He is a very greedy boy, and he would like to have more sausages than anybody else, even though his mother will have made him a lovely meal when he gets home! But everyone is allowed two sausages and no more. When it is Brian's turn to

be served, he says, "Oh, please can I have four sausages, because I won't be having any dinner when I get home!"

Q: Why does Brian say this?

4. Jill wanted to buy a kitten, so she went to see Mrs. Smith, who had lots of kittens she didn't want. Now Mrs. Smith loved the kittens, and she wouldn't do anything to harm them, though she couldn't keep them all herself. When Jill visited she wasn't sure she wanted one of Mrs. Smith's kittens, since they were all males and she had wanted a female. But Mrs. Smith said, "If no one buys the kittens I'll just have to drown them!"

Q: Why did Mrs. Smith say that?

5. One day Aunt Jane came to visit Peter. Now Peter loves his aunt very much, but today she is wearing a new hat; a new hat which Peter thinks is very ugly indeed. Peter thinks his aunt looks silly in it, and much nicer in her old hat. But when Aunt Jane asks Peter, "How do you like my new hat?", Peter says, "Oh, its very nice".

Q: Why does he say that?

6. Helen waited all year for Christmas, because she knew at Christmas she could ask her parents for a rabbit. Helen wanted a rabbit more than anything in the world. At last Christmas Day arrived, and Helen ran to unwrap the big box her parents had

given her. She felt sure it would contain a little rabbit in a cage. But when she opened it, with all the family standing round, she found her present was just a boring old set of encyclopedias, which Helen did not want at all! Still, when Helen's parents asked her how she liked her Christmas present, she said, "It's lovely, thank you. It's just what I wanted".

Q: Why did she say this?

7. Late one night old Mrs. Peabody is walking home. She doesn't like walking home alone in the dark because she is always afraid that someone will attack her and rob her. She really is a very nervous person! Suddenly, out of the shadows comes a man. He wants to ask Mrs. Peabody what time it is, so he walks towards her. When Mrs. Peabody sees the man coming towards her, she starts to tremble and says, "Take my purse, just don't hurt me please!"

Q: Why did she say that?

8. A burglar who has just robbed a shop is making his getaway. As he is running home, a policeman on his beat sees him drop his glove. He doesn't know the man is a burglar, he just wants to tell him he dropped his glove. But when the policeman shouts out to the burglar, "Hey, you! Stop!", the burglar turns round, sees the policeman and gives himself up. He puts his hands up and admits that he did the break-in at the local shop.

Q: Why did the burglar do that?

Physical stories

9. Two enemy powers have been at war for a very long time. Each army has won several battles, but now the outcome could go either way. The forces are equally matched. However, the Blue army is stronger than the Yellow army in foot soldiers and artillery. But the Yellow army is stronger than the Blue Army in air power. On the day of the final battle, which will decide the outcome of the war, there is heavy fog over the mountains where the fighting is about to occur. Low-lying clouds hang above the soldiers. By the end of the day the Blue army has won.

Q: Why did the Blue army win?

10. A burglar is about to break into a jewellers' shop. He skillfully picks the lock on the shop door. Carefully he crawls under the electronic detector beam. If he breaks this beam it will set off the alarm. Quietly he opens the door of the store-room and sees the gems glittering. As he reaches out, however, he steps on something soft. He hears a screech and something small and furry runs out past him, towards the shop door. Immediately the alarm sounds.

Q: Why did the alarm go off?

11. Mrs. Simpson, the librarian, receives a special book which she has to catalogue and find an appropriate place for. She has to decide which section to file it under. The library is very big, and has different sections on many different subjects. The new book is about plants and their medical uses, and is heavily illustrated. However, Mrs. Simpson does not put it on the shelf with the rest of the books on botany. Neither does she put it with the books on medicine. Instead, she carefully takes it into a separate room. In this room all the books are kept in special cases, and the temperature is kept constant.

Q: Why did she do this?

12. Henry is preparing for a big dinner party. He is famous for his excellent mayonnaise. He has bought lots of fresh eggs. The recipe says, "Carefully separate the yolks of six eggs and add oil very gradually". He has already bought easily enough dessert to feed everyone. However, he now looks up the recipe for meringues. Henry will not waste anything.

Q: Why does Henry make meringues?

13. Paul is very rich, and today he is going to buy an expensive new car. He is considering whether to make a single payment, or whether to spread the cost over the year. If he pays in monthly installments, the dealer will charge five percent interest on the loan. His bank currently gives him eight percent interest on the money in his

account. Even though he has easily enough money to pay the full amount, he decides to pay by monthly installments.

Q: Why does he do that?

14. Old Mrs. Robinson is very frail. One day she slips on her icy door step and falls on her side. She gets up right away, although she feels quite bruised and shaken. The next day her leg feels very stiff and she can scarcely walk. She makes her way to the doctors. As soon as the doctor hears about the fall, and sees her swollen side, he says, "Go immediately to casualty". At the casualty department they take an X-ray.

Q: Why did they take an X-ray?

15. Sarah is very long-sighted. She has only one pair of glasses, which she keeps losing. Today she has lost her glasses again and she needs to find them. She had them yesterday evening when she looked up the television programs. She must have left them somewhere that she has been today. She asks Ted to find her glasses. She tells him that today she went to her regular early morning keep fit class, then to the post office, and last to the flower shop. Ted goes straight to the post office.

Q: Why is the post office the most likely place to look?

16. John is going shopping. He buys a nice new desk lamp, for his study. He needs a light bulb for his new lamp. He goes from the furniture department to the electrical

department. In the electrical department he finds that there are two brands of light bulb of the right kind. Everbrite light bulbs cost less in single packs than Literite bulbs. However, only Literite bulbs come in multi-packs of six. John buys the multi-pack, even though he only needs one bulb.

Q: Why does John buy the Literite bulbs?

Examples of scoring criteria for the stories:

2 = full and complete answer;

1 = incomplete or partially correct answer;

0 = incorrect answer

ToM story 1: "Why will Jim look in the cupboard for the bat?"

2 = reference to Simon having lied, being a liar, Jim knowing Simon lies, etc.

1 = reference to facts without explicit mention of lying, e.g. that's where it is really.

0 = reference to general, story non-specific information, e.g. things are usually left in cupboards.

ToM story 2: "Why did the prisoner say that?"

2 = reference to fact that other army will not believe and hence look in other place, to prisoner's realisation that that's what they'll do, or reference to double bluff.

1 = reference to outcome (e.g. to save his army's tanks) or simple lying (to mislead them, to lie).

0 = reference to motivation that misses point of double bluff (e.g. because he was scared and wanted to tell the truth).

Physical story 9: "Why did the Blue Army win?"

2 = Reference to both weather conditions and relative ground superiority or inability of other army's planes to be useful in fog (N. B. names of armies are unimportant).

1 = Reference either to weather or to relative superiority on ground versus air.

0 = Reference to irrelevant or incorrect information (e.g. they won because they had better planes).

Physical story 10: "Why did the alarm go off?"

2 = Reference to animal, which the burglar disturbed, setting off the alarm (N. B. type of animal unimportant, e.g. cat, mouse, rat, all okay).

1 = Reference to burglar setting off the alarm, e.g. being startled by animal and so crossing the beam.

0 = Reference to irrelevant or incorrect facts (e.g. the animal's screech set off the alarm).

APPENDIX 3: QUICK TEST

FORM 2 PICTURES AND WORD LIST

2

cans
chewing
falling
dinner
cow
groceries
hat
sitting
country
danger
plate
river
tasting
shelves
sky
table
carelessness
manners
adding
injury
merchandise
waitress
horizon
retail
irrigation
unaware
current
fertile
descending
spacious
proprietor
inattentive
indulging
precipitation
freshet
transom
consumption
aquatic
perilous
terrain
imminent
foresight
condensation
satiation
visceral
bovine
replete
prehension
ingress
celerity

APPENDIX 4: COGNITIVE ESTIMATES TEST

QUESTIONS AND SCORING CRITERIA

COGNITIVE ESTIMATION TEST

Please make the best guess you can in answer to each of these questions:

1. What is the height of the Post Office Tower (now called the BT Tower)?

_____ feet

2. How fast do race horses gallop?

_____ miles per hour

3. What is the best paid job or occupation in Britain today?

_____

4. What is the age of the oldest person in Britain today?

_____ years

5. What is the length of an average man's spine?

_____ feet and inches

6. How tall is the average English woman?

_____ feet and inches

7. What is the population of Britain?

_____ million

8. How heavy is a full pint bottle of milk?

_____ pounds (lbs)

9. What is the largest object normally found in a house?

_____

10. How many camels are there in Holland?

_____

Scoring criteria

1. PO Tower	< 60'	60'	<100'	100' to 800'	> 800'	1500'	> 1500'
	= 3	= 2	= 1	= 0	= 1	= 2	= 3
2. Horses	< 9	< 15		15 to 40	> 40	50	> 50
	= 3	= 2		= 0	= 1	= 2	= 3
3. Job	Manual	Blue-collar		Professional	Royalty/entrepreneurs		
	= 3	= 2		= 1	= 0		
4. Oldest	< 103	103		104 to 113	114	115	> 115
	= 3	= 1		= 0	= 1	= 2	= 3
5. Spine	< 1'6"	1'6"		1'7" to 3'11"	4'	> 4'	5'
	= 3	= 1		= 0	= 1	= 2	= 3
6. Woman	< 5'2"	5'2"	5'3" to 5'8"		< 5'11"	< 6"1"	> 6'
	= 3	= 1	= 0		= 1	= 2	= 3
7. Britain	< 2	< 3	< 10	10 to 499	500	> 500	> 1000
	= 3	= 2	= 1	= 0	= 1	= 2	= 3

8. Milk	< 1	1	1 to 3	3	> 3
	= 3	= 1	= 0	= 1	= 3

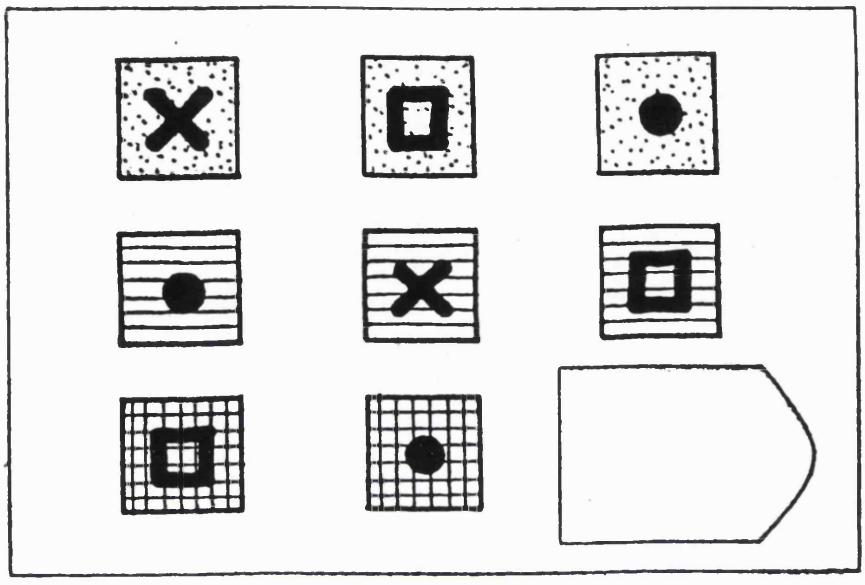
9. Object	< Carpet	Carpet	Sofa, sideboard	Bed, wardrobe
	= 3	= 2	= 1	= 0

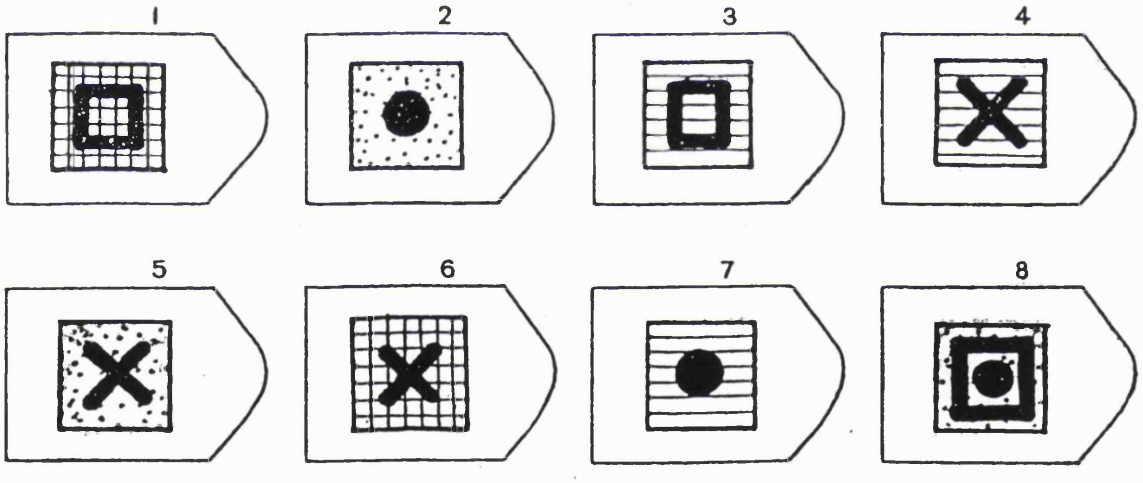
10. Camels	> 50	None
	= 3	= 1

APPENDIX 5: RAVEN'S PROGRESSIVE MATRICES

EXAMPLE OF ONE STIMULUS

7





APPENDIX 6: EMBEDDED FIGURES TEST

INSTRUCTIONS AND EXAMPLE OF ONE STIMULUS (WITH TO-BE-FOUND OBJECT SUPERIMPOSED)

Instructions for Embedded Figures Test

a) Training

In this task you will be shown some pictures, and your aim will be to find, as fast as you can, objects which are hidden in the pictures. Sometimes the object will be easy to find, and other times it will be more difficult.

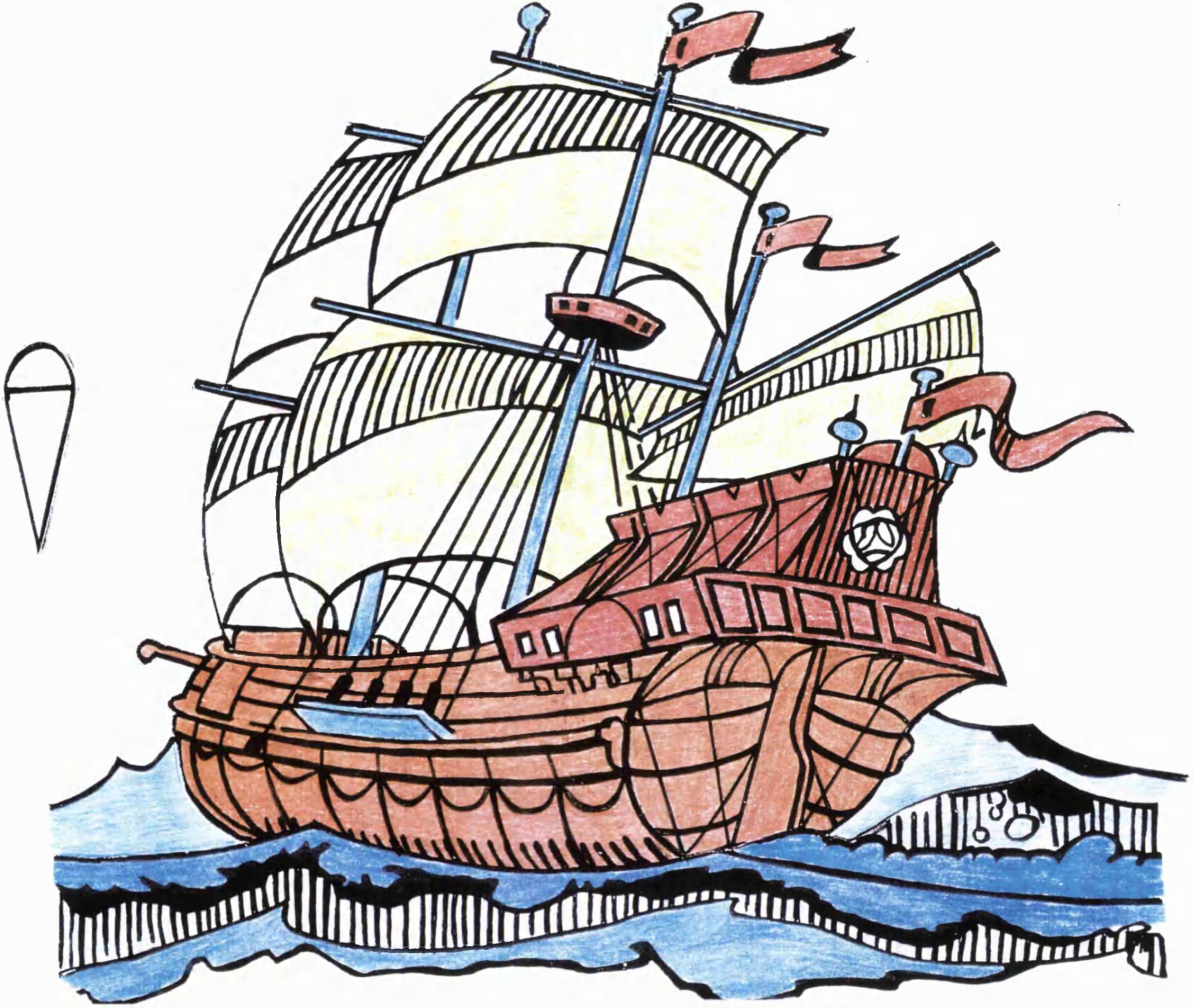
Each time, the object that you have to find will be shown by a cardboard cutout. This cutout will be the same shape and size, and the same way up, as the object in the picture.

Here are a few practice pictures. I'm going to time you, so as fast as you can, please find this XXXX in the picture. When subject has located it, he/she is asked to place the cutout in the correct place on the picture.

Experimenter points out that when the subject searches, he/she can either point at the object and outline it with their finger, or search using the cutout. Experimenter also points out that colouring and extra lines crossing the shape are unimportant.

b) Experiment

For each of the 8 experimental pictures, the experimenter says, "As fast as you can, find this XXXX in the picture". A time limit of 2 minutes is set for each picture.



APPENDIX 7: APPROVAL LETTER FROM ETHICS COMMITTEE

UCL
HOSPITALS

The University College London Hospitals

The Joint UCL/UCLH Committees on the Ethics of Human Research

Committee Alpha Chairman: Professor André McLean

Please address all correspondence to:
Iwona Nowicka
Research & Development Directorate
9th Floor, St Martin's House
140 Tottenham Court Road, LONDON W1P 9LN
Tel. 0171- 380 9579 Fax 0171-380 9937
e-mail: i.nowicka@academic.uclh.nthames.nhs.uk

Dr C Frith
Wellcome Principal Research Fellow
Institute of Neurology
Wellcome Department of Cognitive Neurology
UCL
12 Queen Square

31 August, 1999

Dear Dr Frith

Study No: 99/0199*(Please quote in all correspondence)*
Title: **Theory of mind, central coherence and schizotypy**

I have reviewed the above protocol and agreed it by Chairman's Action, subject to ratification by the whole committee. You may go ahead with your study.

Please note that it is important that you notify the Committee of any adverse events or changes (name of investigator etc) relating to this project. You should also notify the Committee on completion of the project, or indeed if the project is abandoned. **Please remember to quote the above number in any correspondence.**

Yours sincerely

I. Nowicka

pp.

Professor André McLean, BM BCh PhD FRC Path
Chairman

APPENDIX 8: INFORMATION SHEET AND CONSENT FORM

FOR PARTICIPANTS

CONFIDENTIAL

INFORMATION SHEET FOR VOLUNTEERS

Study Title: Theory of Mind, Central Coherence and Schizotypy

Investigators: Prof. C. D. Frith, Wellcome Department of Cognitive Neurology, Institute of Neurology, UCL, Queen Square, London WC1N 3BG
Tel: 0171 833 7457

Dr. G. J. Pickup, Department of Clinical Health Psychology, UCL, Gower Street, London WC1E 6BT
Tel: 0171 380 7897

You are invited to participate in a research project which investigates the relationship between certain personality traits, the ability to work out what other people think in particular situations, and the speed with which you can find hidden objects within pictures. As a healthy volunteer, the data you provide will give us information about the normal variation in people's understanding of social situations.

You will be asked to complete a brief screening questionnaire asking about some of your experiences and thoughts. After you have completed it, you will be told whether or not you are eligible to take part in the study.

If you take part, you will then complete a longer questionnaire, answer questions on some stories, complete a few short intelligence tests, and be asked to find some hidden objects within pictures. This interview takes about 50 minutes in total. Your answers to all these questions will be completely confidential and identified only by a number rather than by your name. You will receive £10 for taking part, which is a 'thank you' gesture from us.

There are no potential risks involved in the research.

You do not have to take part in this study if you do not want to. If you decide to take part you may withdraw at any time without having to give a reason.

All proposals for research using human subjects are reviewed by an ethics committee before they can proceed. This proposal was reviewed by the Joint UCL/UCLH Committees on the Ethics of Human Research.

Please feel free to ask any questions about the research, and we will do our best to answer them.

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CONSENT FORM FOR VOLUNTEERS

Study Title: Theory of Mind, Central Coherence and Schizotypy

Investigators: Prof. C. D. Frith, Wellcome Department of Cognitive Neurology, Institute of Neurology, UCL, Queen Square, London WC1N 3BG
Tel: 0171 833 7457

Dr. G. J. Pickup, Department of Clinical Health Psychology, UCL, Gower Street, London WC1E 6BT
Tel: 0171 380 7897

I have read the information sheet about this study

I have had an opportunity to ask questions and discuss this study

I have received satisfactory answers to all my questions

I have received enough information about this study

I have spoken to Graham Pickup about this study

I understand that I am free to withdraw from this study . . . .

* at any time
* without giving a reason for withdrawing

I agree to take part in this study

Signed ..... (Volunteer) Date .....

Signed ..... (Graham Pickup, Experimenter)

Date .....