Visual Attention Shifting Ability in Schizophrenia across Covert Orienting of Attention and Anti-saccade Tasks

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Abstract

The disabling effects of schizophrenia, as well as the difficulty in addressing all the associated deficits through treatment are well documented. Recently more research has focused on characterising cognitive deficits related to schizophrenia, as due to their enduring nature, and relation to functioning ability they are viewed as a therapeutic target. The aim of this thesis was to investigate the ability of individuals diagnosed with schizophrenia, as well as in relation to the schizophrenia spectrum, to shift attention focus both within the visual field (covert attention) and by directing their eye-movements (overt attention). In particular the ability to use task information to modify strategies for better performance was examined. Participants, consisting of individuals with a diagnosis of schizophrenia, an age appropriate comparison group and students assessed for schizotypal traits, completed two covert cueing tasks, and two anti-saccade tasks, designed to measure both reflexive and voluntary attention shifts. Individuals with schizophrenia showed consistent impairments across the tasks, with lower sensitivity to targets and slower response time for the covert attention studies, and higher error rates and longer latencies for the anti-saccade tasks. Schizotypy scores were also related to some performance measures, with higher scorers exhibiting lower hit rates for the cueing study, and longer latencies in the classic anti-cue task. The inability to inhibit eye-movements was also consistently related to the schizophrenia spectrum. All participants, including those in the schizophrenia group, used the task information to change their attention strategies accordingly; this suggests that individuals with schizophrenia are able to use some degree of top-down voluntary control of both overt and covert attention. Thus strategic attention appears preserved in relation to the schizophrenia spectrum, but the basic deficits, which were shown to be consistent, could present a target for treatments as they are present even when participants are receiving medication.
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Chapter One

Introduction and Literature Review

1.1. Overview

The first chapter of this thesis is designed to outline the relevant literature and concepts that form the background for the studies that follow. This will begin with a general background to Schizophrenia as a disorder as well as the concept of the Schizophrenia Spectrum and Schizotypal Traits. It will then outline the background to the areas of research within this thesis, namely covert attention and the cueing task, and overt attention and the anti-cue task, as well as the background of research into the performance on these tasks in relation to schizophrenia. Following this, the background, and the theory behind the method of analysis used in the first two experimental chapters will be outlined. This chapter will then conclude with an outline of the aims and overarching research questions that are investigated within the experimental chapters of this thesis.

1.2. Schizophrenia Background

1.2.1. Brief History and Overview of Disorder

The term ‘schizophrenia’ has only been around since the early 1900s when Blueler first used it to describe the group of disorders (catatonia, hebephrenia and paranoid dementia) previously defined by Kraeplin under the name of ‘dementia praecox’ (as cited by Cutting, 1985). The term schizophrenia does not, as commonly believed, mean split personality, but actually refers to the individuals having a ‘split mind’, as Kraeplin thought that underlying the symptoms was a neurological divide that meant that the two hemispheres of the brain were unable to communicate with each other. Kraeplin (1920; as cited by Tandon, Nashrallah & Keshavan, 2009) emphasised the importance of early onset, chronic course and poor outcome as defining features, whereas Blueler believed ‘negative’ symptoms (i.e. blunt affect and loosening of associations) were primary to the disorder (as cited by Cutting, 1985). The positive symptoms were emphasised by the Schnieder (1959) who termed them first rank...
symptoms, and these gained prominence in the 1970’s within present-state assessment tools (Andreasen & Flaum, 1991). These ideas of positive and negative symptoms, as well as the idea of prolonged, or chronic, course have endured and are evident in currently used diagnosis criteria detailed below.

Currently, schizophrenia is viewed a complex disorder that has a multifaceted aetiology (Raine, 1991), with diverse symptoms and a range of illness course and outcomes following treatment. It has been placed in the top ten most disabling illnesses by the World Health Organisation, and due to the poor prognosis of the disorder, for many the disability is lifelong (Murray & Lopez, 1996; cited Williamson, 2006). Schizophrenia is also associated with a higher suicide risk, approximately one-third of individuals with schizophrenia attempt suicide and about 5% succeed at some point (Tandon et al., 2009). The prevalence rate for schizophrenia is also relatively high, with a 0.7% risk if development over a lifetime (Tandon, Keshavan, & Nasrallah, 2008).

Schizophrenia is characterised by psychosis (a separation of self from reality), and is viewed as manifesting itself in symptoms that have been traditionally grouped into positive (or cognitive-perceptual) symptoms such as hallucinations and delusions, and negative (or interpersonal symptoms) symptoms such as flattening of affect and poverty of speech or thought (American Psychiatric Association, 2000) with a third factor of disorganised symptoms, such as disordered speech and odd behaviour, also being emphasised by some researchers (Liddle, 1987; Raine et al., 1994). Although course of the illness varies greatly it is classically identified following an acute stage, which involves mostly strong presentations of the positive and disorganised symptoms, this then gives way to either a chronic stage, that can involve the presentation of more negative symptoms, or a remission; many individuals go on to have periods of relapse to acute phases (Tandon et al., 2009).

The varied risk factors for this disorder can be broadly defined into three categories: environmental risk factors, for example living in a city and a history of migration are linked to higher incident rates (Tandon, Keshavan & Nasrallah, 2008), biological risk factors such as malnutrition and prenatal viral infections (Williamson, 2006) and genetic risk factors, for example adopted children with a biological mother diagnosed with schizophrenia having higher rates of schizophrenia themselves (Tienari et al., 2000). However, there has not been a direct link between any one factor and the development of schizophrenia and the underlying mechanisms resulting in the disorder
are not fully understood. This makes research into this disorder important as it may contribute to a better understanding, and ultimately a better treatment, or even prevention of development of schizophrenia, which is highly desirable.

1.2.2. Classification of Schizophrenia in Commonly Used Diagnostic Tools

The current edition of the World Health Organization’s International Statistical Classification of Diseases and Related Health Problems (ICD-10; World Health Organization, 1992) lists schizophrenia under ‘Schizophrenia, Schizotypal and Delusional Disorders (F20-F29)’ stating that schizophrenia is the most important member of this group. The ICD-10 outlines schizophrenia as being characterised both by distorted thinking and by inappropriate or blunted affect, thus incorporating both positive and negative aspects of schizophrenia as key features. Listed among the most important pathological phenomena are thought broadcasting (the belief that their thoughts are able to be read by others), delusions of control, hallucinatory voices commenting or discussing the patient in the third person and negative symptoms. It should also be noted that Schizoaffective disorder is included in this section, albeit under its own heading (F25), defined as an episodic disorder that has both affect and schizophrenic symptoms but neither are dominant enough to warrant a differential diagnosis of either.

The American Psychiatric Association’s Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; American Psychiatric Association, 2000), which is used in the United States, encompasses stricter criteria for diagnosis of schizophrenia where individuals must have displayed a characteristic symptom (delusions, hallucinations, disorganized speech, disorganized behaviour and negative symptoms) for at least a one month period, and also social/occupational dysfunction that has lasted over a six month period, emphasising the enduring nature of the disorder. It also stipulates exclusion of an affective component and exclusion of side effect of a substance or existing medical condition. Although the DSM-IV-TR includes subtypes, the most recent version of the manual (DSM-V; American Psychiatric Association, 2013) excludes subtypes, citing that patients symptoms, on which the subtypes are based, were too changeable to be a useful diagnosis tool.
1.2.3. Current Treatments in Schizophrenia

According to the current guidelines within the United Kingdom for the treatment of individuals diagnosed with schizophrenia, anti-psychotic drugs are recommended as the first-line treatment, with Cognitive Behavioural Therapy sessions and family therapy sessions suggested for those whose who have suffered an acute episode (National Institute for Health and Care Excellence, 2009).

Antipsychotic medication can be broadly described as either typical (neuroleptic) or atypical (second generation). The typical class of antipsychotics began being used in the 1950’s when chlorpromazine, originally designed as an antihistamine, was found to have a successful therapeutic effect on individuals with schizophrenia (Frith, 1992). This was followed with several other drugs which also had positive effects on individuals with schizophrenia. Although it was initially unclear how the drugs were having effect, it has been shown that they block the D2 dopamine receptors, and furthermore, their ability to do so is strongly related to their efficacy in treating psychosis (Seeman, Lee, Chauwong, & Wong, 1976). This finding lead to the ‘dopamine hypothesis’ of schizophrenia, which suggests that an excess of dopamine, specifically in the mesolimbic system, is the cause of schizophrenia, and the drugs ability to block these receptors leads to a control of dopamine and thus a reduction of symptoms (McKim, 2007). There were, however, disadvantages to typical antipsychotics, because as well as blocking dopamine receptors in the mesolimbic system, they also blocked dopamine in the nigrostriatal system; which is responsible for the integration of smooth movements, this resulted in alterations in movement similar to those found in Parkinson’s disease. This along with the side effects of tardive dyskinesia (repetitive movements of the face that can be persistent after the drug is stopped, which have been held responsible for high levels of non-compliance of typical antipsychotics), and so-called refractory patients, who are poor responders to these drugs, made it desirable for other drugs with different actions to be developed (Kane, 1999).

The first atypical antipsychotic, Clozapine, that came into more common use in the early 1990s, despite being developed as early as 1960s (Tandon, Nasrallah, & Keshavan, 2010), was found to be effective but without the parkinsonian and tardive dyskinesia side effects. However, due to its ability to cause potentially fatal Agranulocytosis, where the white blood cell count becomes dangerously low, it is still
used with caution today. Clozapine, and other subsequently developed atypical antipsychotic drugs, have been shown to also block dopamine receptors, but they have high affinities for the D3 and D4 receptors, which are less present in the nigrostriatal system, thus offering an explanation for the reduction in side effects (McKim, 2007).

Another notable difference between the two types antipsychotics is that the atypical antipsychotics also block the serotonin 5HT2A receptor, and this, along with the fact that psychosis inducing drugs such as LSD are agonists at these receptors have cause suggestions of a role for serotonin in schizophrenia (McKim, 2007). Although atypical drugs have some clear advantages, including their ability to treat some refractory patients (Kane, 1999), and negative symptoms, they also have significant side effects including metabolic and cardiovascular problems. It is also important to note that the mortality gap between individuals diagnosed with schizophrenia and the general population has widened over the past two decades despite the widespread use of these antipsychotics (Tandon et al., 2010), suggesting that atypical antipsychotics are not prolonging the lives of the patients, perhaps partially due to side effect complications.

Studies using healthy subjects indicate that antipsychotic medication can have an effect on performance across several tasks. Wezenberg, Sabbe, Hulstijn, Ruigt, and Verkes (2007) found that when healthy subjects were given either olanzapine (atypical anti-psychotic), haloperidol (typical anti-psychotic), lorazepam (benzodiazepine), mirtazapine (a noradrenergic and specific serotonergic antidepressant) or a placebo they reported greater sedative effects of the drugs when compared to the placebo group. The drugs, except haloperidol, had a negative effect on the tasks including measures of sustained attention, speed of processing (the symbol coding subtest of the WAIS), a verbal memory task and the ability to follow a target with their eyes (smooth pursuit task). In a study conducted by Barrett, Bell, Watson, and King (2004) single doses of risperidone and amisulpride had significant effects on attention (visual latent inhibition), and risperidone and chlorpromazine also affected eye-movements (antisaccade errors), although none of these drugs had an effect on verbal fluency or executive function. This suggests that there are some effects of anti-psychotic medication on some cognitive tasks in individuals with an absence of psychopathology; however there is a lack of consistency across drugs.

Cognitive Behavioural Therapy (CBT) is generally used to help patients who have persistent psychotic symptoms following pharmacological treatment. It works
under the basis that psychotic symptoms may be due to misinterpretations and irrational attributions (Tandon et al., 2010), which are targeted to be identified and appraised by the patient through CBT and therefore reduced. The effectiveness of this is questioned by a meta-analytic review conducted by Lynch, Laws, and McKenna (2010) who found that CBT was not effective at reducing symptoms or preventing relapse. Family therapy, the other psychological therapy that is recommended by NICE, involves working with the family in order to reduce expressed emotion, particularly negative, within the family of the individual diagnosed with schizophrenia. Pharoah, Mari, Rathbone, and Wong (2010) conducted a systematic review into family therapy and concluded only that family interventions ‘may’ reduce relapse and hospitalisation but the evidence is not conclusive, and that it did not prevent suicide attempts. It is also not appropriate when the individual is not in close contact with their family.

Treatments currently on offer in the United Kingdom do appear to offer some relief to many patients diagnosed with schizophrenia but the antipsychotics do not appear to effectively treat negative symptoms and have concerning side effects, and psychological therapies, which are mainly used for anti-psychotic resistant patients have not been shown to be efficacious. Therefore, there is a definite need for development of treatment that alleviates symptoms in schizophrenia without the problematic side effects of the current medication.

1.2.4. Schizophrenia as a Spectrum Disorder

For many years schizophrenia had been seen as a dichotomous entity reflecting the clinical need for identification of individuals requiring treatment. However, in the 1960’s researchers began to suggest that, as there was no clear single cause of schizophrenia, it was likely that the interaction between the different aetiological factors contributing to schizophrenia could cause varying degrees of illness. The suggestion was that this could include individuals who did not require treatment, yet due to some expression of their genetic vulnerability, displayed unusual (schizotypal) behavioural traits (Meehl, 1962). Research conducted by Kety, Roseenthal, Wender & Schulsinger (1971) looked at schizophrenia symptoms in individuals who were adopted at a young age and who had first degree relatives diagnosed with schizophrenia, thus retaining the genetic vulnerability but not the unfavourable environmental factors. The results of these studies were that some of these individuals with schizophrenic relatives, who did not develop schizophrenia, still exhibited abnormal behaviour patterns. These
patterns later formed the DSM-III criteria for Schizotypal Personality Disorder (APA, 1980), and have also been more recently replicated by a larger scale adoption study (Tienari et al., 2000). Schizotypal Disorder (F21) also features in the ICD-10 (ICD-10, 1994), in the same section as other schizophrenic disorders, defined as ‘a disorder characterized by eccentric behaviour and anomalies of thinking and affect which resemble those seen in schizophrenia, though no definite and characteristic schizophrenic anomalies occur at any stage’, suggesting that schizophrenia is perhaps better described as a cluster of disorders or syndromes rather than a single entity. The DSM V has also made Attenuated Psychosis Syndrome a proposed condition that requires further research before formal inclusion; they propose that this category would include individuals with minor versions of symptoms relevant to psychosis, who could be targeted for early intervention.

Other researchers have further suggested that based on the increasing number and diversity of risk factors implicated in schizophrenia, the disorder, or traits linked to it, are actually distributed throughout the normal population as well as the clinical population and the divide is only there for clinical convenience (Murray and Fearon, 1999). As these traits are behavioural and observable, much work has been done on developing a way of assessing these traits in order to study contributing factors in schizophrenia without confounds of using a clinical population, such as medication and comorbid diagnosis. This has resulted in an increasing number of researchers studying these ‘schizotypal’ traits and relating factors. The current thesis takes its samples from two groups, the first group comprises of students, who are assessed for schizotypal traits, and the second group are individuals diagnosed with schizophrenia and community comparison subjects. This is in order to examine which deficits (if any) are related specifically to schizophrenia and which extend into the normal population in relation to traits linked to the schizophrenia spectrum.

1.3. Cognitive Deficits in Individuals with Schizophrenia

There has been a growing body of research in recent years towards measurable cognitive deficits within individuals with a diagnosis of schizophrenia; with interest in viewing cognitive deficits as targets for treatment (Cella, Reeder, & Wykes, 2014; Gharraeipour & Scott, 2012; Szoke et al., 2008). The importance of using cognitive tests as outcome measures during clinical trials has also been emphasised (Nuechterlein et al., 2004), being promoted due to their stable nature when compared to the more
episodic psychotic symptoms (Nuechterlein et al., 1992). These suggestion are supported by research indicating that cognitive deficits are negatively related to better functioning in schizophrenia; with higher levels of cognitive functioning at first presentation related to higher rates of symptom remission (Robinson, Woerner, & McMeniman, 2004) and better social functioning (Boden, Abrahamsson, Holm, & Borg, 2014). In response to this focus on cognitive deficits the National Institute for Mental Health in the USA have set up the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) initiative, which is dedicated to developing cognitive-enhancing drugs for schizophrenia (Marder & Fenton, 2004).

Several meta analyses have been conducted on the large body of research in order to identify the consistent deficits in individuals with a diagnosis of schizophrenia; identifying attention, working memory, verbal fluency and executive function as consistent deficits (Nuechterlein et al., 2004; Robinson et al., 2004; Szoke et al., 2008), along with speed of processing (Nuechterlein et al., 2004) and visual-spatial abilities (Robinson et al., 2004) implicated by some. The identification of deficits shown in these areas in individuals with schizophrenia on specific tasks could indicate underlying neural problems; and their relationships with different symptom groups could form targets for different medication and therapeutic interventions, as suggested above. Therefore, as tasks with stable deficits can be good measures of treatment efficacy, the current thesis focuses on identifying consistent deficits within this group on visual attention measures, with the background to these measures detailed below.

1.4. Visual Attention

Visual attention, particularly the control of attention, has been proposed by some researchers as one of the cognitive deficits that should be a priority target for treatment for individuals diagnosed with schizophrenia (Luck & Gold, 2008; Lustig, Kozak, Sarter, Young, & Robbins, 2013). Posner and Petersen (1990) define visual attention as comprising of three entities based on their relatively distinct underlying networks. The first is maintaining a vigilant or alert state, the second is orienting to stimuli appearing in the visual field, and the third is detecting signal for conscious processing. Individuals with schizophrenia have been shown to have deficits in vigilance through consistently poorer performance on the continuous performance task, that requires participants to maintain attention in order to respond to in frequently occurring targets in a long list of distractors (Cornblatt, Lenzenweger, & Erlenmeyer-
Kimling, 1989; Epstein, Keefe, Roitman, Harvey, & Mohs, 1996; Hahn et al., 2014; Mirsky, Yardley, Jones, Walsh, & Kendler, 1995). This has also been shown to be consistent for non-medicated schizophrenia patients (Epstein et al., 1996), relatives of patients (Chen et al., 1998) and in relation to schizotypy (Chen, Hsiao, & Lin, 1997). This thesis is concerned with examining the other two attention types of orienting and detecting signals that make up selective attention, in relation to the schizophrenia spectrum. These will be examined in overt attention, where attention can be measured through the eye-movements of the participants, which focuses visual optimal visual processing on the target stimuli. As well as covert attention, where attention is moved within the visual field, without eye-movements and therefore has to be inferred by performance measures. This covert process theoretically precedes overt attention shifts by selecting relevant stimuli to orient the visual processing system towards (Kowler, Anderson, Dosher, & Blaser, 1995).

Therefore, two paradigms, the anti-saccade paradigm for overt attention, and the Covert Orienting of Visual Attention Task (COVAT) for covert attention are reviewed below, which incorporate both orienting to the stimuli and signal detection. These will form the basic methods for the experimental chapters in this thesis, with the COVAT forming the basis for the second and third chapters, and the anti-saccade paradigm being utilized in the fourth chapter.

1.4.1. Overt Attention Measures: Pro and Anti-saccades

1.4.1.1. Background to the Anti-Saccade Task

There are two major classes of saccades that have been defined, the first type is externally driven and involves automatically orienting to a stimuli, the second type are internally controlled through voluntary mechanisms (Gooding & Basso, 2008). Hallett designed a study in 1978 where he used several methods to try and look at the second voluntary type of saccade. In his study participants were asked to look at a computer screen at a small blue-green circle stimulus which would then jump to the left or right by 15.3°, and participants were requested to move their eyes in the opposite direction the same distance as the stimulus had displaced. This basic task has now become commonly known as the anti-saccade task. In the original study, Hallett found that in the anti-saccade task (as opposed to when participants were just required to make reflexive saccades towards the new stimulus position), participants eye-movements
were characterised by long latencies (time between onset of the peripheral stimuli and onset of initial saccade) and incorrect reflexive primary saccades followed by corrective secondary saccades. These two key findings of reflexive error saccades and longer latencies on the anti-saccade trials have been well established across many research studies (Barton et al., 2002; Dafoe, Armstrong, & Munoz, 2007; Franke, Reuter, Schulz, & Kathmann, 2007; Klein, Brugner, Foerster, Muller, & Schweickhardt, 2000; Massen, 2004; O’Driscoll, Lenzenweger, & Holzman, 1998; Panouilleres et al., 2009). For peripheral stimuli, correctly executed anti-saccades have also been shown to have smaller amplitude than pro-saccades (Dafoe et al., 2007).

In Hallett’s study the error saccades were found to have shorter latencies than correct response saccades, a finding replicated by other studies (Brownstein et al., 2003; Schaeffer et al., 2013; Weber, Durr, & Fischer, 1998), the amplitudes for the error saccades that were also significantly less, as they were often quickly corrected by the secondary saccades. This again has been replicated by subsequent studies (Massen, 2004; Mokler & Fischer, 1999), although it is not always analysed as a performance measure as the focus is generally more on errors. This lack of analysis of the saccade amplitude measure, and to some degree the saccade latency measure, has been criticised by some researchers, who believe that not utilizing these measures mean that researchers may not be presenting a full picture of anti-saccade responding (Antoniades et al., 2013).

Based on these findings several researchers suggest that the anti-saccade task involves two stages, the first is the inhibition of a reflexive saccade towards the target, this is then followed by the generation of a voluntarily guided saccade in the opposing direction (Everling & Fischer, 1998; S. B. Hutton, 2008; Rommelse, Van der Stigchel, & Sergeant, 2008). This view suggests that anti-saccade errors are therefore due to the inability to inhibit the initial reflexive response, and the longer latencies on the correctly executed anti-saccade trials represent the longer processing involved in executing both the inhibition and execution steps. More recently other researchers have suggested that the programming of pro- and anti-saccades occurs simultaneously, and that they compete, with anti-saccades over a certain activation threshold overcoming the pro-saccade response (Massen, 2004; Mokler & Fischer, 1999). Several researchers have looked at the competition between anti- and pro-saccade responses through mixed pro- and anti-saccade trial presentation. In the first of these studies Hallett and Adams (1980) conducted a task where anti-saccade trials (signalled by a tone and a visual sign)
were randomly presented with pro-saccade trials, instead of in a consistent block like in the original task. They found that saccade latencies were still longer for the anti-saccade trials despite being intermixed. There were errors made on the pro-saccade trials for the intermixed, although at lower rates than on the anti-saccade trials. Errors on the pro-saccade trials have been found in several other anti-saccade tasks with intermittent presentations of pro-saccade trials (Barton et al., 2002; Franke et al., 2007; Weiler & Heath, 2014). However, several studies have found that intermittent presentation also increases pro-saccade latencies especially for pro-saccade trials following anti-saccade trials when compared to a pro-saccade task alone (Weiler & Heath, 2014). These errors and increased latencies on the pro-saccade trials suggest that the anti-saccade trials were interfering with pro-saccade trials, thus participants are still inhibiting the reflexive responses even when this is what is required.

In another intermittent anti-saccade task, Massen (2004) varied the frequency of anti-saccade trials in each block (25%, 50% and 75% of trials) with the remainder made up of pro-saccade trials; the trial type was signalled prior to the trial beginning by presenting a bar at fixation that differed on orientation for the two trial types. She found that as frequency increased the proportion of errors decreased for the anti-saccade trials, however, she did not report how this effected the pro-saccade trials. For the anti-saccade trials the saccade latencies also decreased with increased frequency, with no significant difference for the pro-saccade trials. Massen suggested that this was in support of the simultaneous activation approach, as when the frequency of the anti-saccades was lower, there was less processing put into generating an anti-saccade meaning that the pro-saccade response was more likely to be activated. It could also be viewed that the participant was preparing to make the more likely response type and it was this that increased the errors, adding to the baseline anti-saccade error rate. This idea of preparation for more likely response types has been supported by Koval, Ford, and Everling (2004) who presented anti-saccade blocks consisting that varied the probability of the target appearing on the left compared to the right across three levels (20%, 50% and 80%), therefore looking at the competition between left and right saccades. Participants made more saccade errors for the less likely direction both in comparison to the more likely direction and the baseline of the equally-likely condition. This supports the role of competition in saccade responses for this task as the participants were again affected by the probability in this task, but this time in relation to the side the response was required to be directed to. The researchers suggested this
was due to motor preparedness in the anti-saccade task for a more likely response interfering with trials where the less likely response was required.

The role of executive function (involving planning, monitoring and inhibition) as well as working memory have been emphasised by many researchers in the anti-saccade task (Nieuwenhuis, Broerse, Nielen, & de Jong, 2004). Correct responses to the anti-saccade task involve the participants being able to maintain and refer to task relevant information (working memory), while filtering out irrelevant information and overriding dominant response (inhibition). There have been several manipulations of the anti-saccade task in order to investigate what effects different factors have on performance on this anti-saccade task.

Two studies by Weber et al. (1998) and Fischer and Weber (1998) increased working memory load, as well as inhibition requirements, through the addition of predictive cues to both pro-saccade and anti-saccade tasks. In the Weber et al. (1998) study the presented a block anti-saccade task with cues appearing again in the opposing location to the target, and thus indicating the location a correct anti-saccade response should be directed to. Instead of the participants utilizing the cue information to aid their performance, they actually produced more errors and had longer latencies compared to a block of anti-saccades presented on their own. In the Fischer and Weber (1998) study participants were given cues immediately prior to target presentation in a pro-saccade task that appeared on the opposing side to the target stimuli. They found that this also increased saccade latencies for the pro-saccade trials, as well as causing error saccades towards the cue. These findings suggest that the although the cue information could have been utilized to improve performance, the increase in inhibition and working memory demands actually worsened performance and that this is evident not only for anti-saccade trials but also for pro-saccade trials which normally do not involve inhibition and have low working memory demands.

1.4.1.2. Anti-Saccades and the Role of Neural Circuits

Early on in anti-saccade research the frontal lobes were examined as possible candidates for underlying neural mechanisms. Guitton, Buchtel, and Douglas (1985) studied eye-movements in epileptic patients who had part of their frontal lobes removed as a treatment. They gave frontal lesion patients and two control groups (consisting of temporal lesion patients and healthy controls) both a pro-saccade task and an anti-saccade task. Both the patient groups and the control group performed the reflexive
saccade task with little errors. In the anti-saccade task, although both the control groups made a reasonably large amount of reflexive gaze errors (about 20% of trials), the frontal lobe lesion patients made significantly more (about 50% of trials) and these errors were not significantly lateralized to one visual field, even when the frontal lobe damage was unilateral. As the IQ of the patients was not affected by the frontal lobe lesions, and the temporal lobe lesion patients did not display the same deficits, the authors concluded that the frontal lobe plays a key part in the suppression of reflexive saccades and control of eye-movements. This evidence of the importance of the frontal lobes in the anti-saccade task can also be taken as supportive evidence of executive function and working memory being fundamental to this task as the frontal lobe has been implicated in underlying both of these cognitive functions (Nieuwenhuis et al., 2004; Walker, Husain, Hodgson, Harrison, & Kennard, 1998). Several studies have since linked the frontal lobe, in particular the prefrontal cortex and the frontal eye-fields, and the performance on the anti-saccade task, both in patients and participants from the non-clinical population (Munoz & Everling, 2004; Nyffeler et al., 2007; Schaeffer et al., 2013; Walker et al., 1998), and have connected it to the preparation of anti-saccades rather than just the eye-movement execution (DeSouza, Menon, & Everling, 2003).

Another area that has been implicated in the control of anti-saccades is the parietal lobe that is typically damaged in patients suffering from attentional neglect, a syndrome where participants have difficulty attending to one side of their visual field, usually the left following right-sided lesions. In a study by Butler et al. (2009) participants with neglect syndrome, which followed right-hemisphere brain damage, were required to complete both pro- and anti-saccade trials in blocks. They showed longer latencies for the pro-saccades where the target was presented to the left, consistent with their neglect. However, they also had a higher number of errors on the anti-saccade task, when compared to the control group which was consistent across the two sides of the visual field. This implies that the underlying damage involved in neglect is also implicated in the anti-saccade task. Unfortunately, in this particular study the brain lesions underlying neglect were diverse, although for many participants the frontal lobes were undamaged which implies that it is likely that more complex neural circuits are involved in the ability to perform the anti-saccade task than just the frontal lobes alone. A network that involves both the frontal and parietal areas underlying anti-saccades, particularly in relation to the preparation of making an anti-
saccade response have been highlighted in fMRI studies (Ford, Goltz, Brown, & Everling, 2005; Jamadar, Fielding, & Egan, 2013). This possible role of the parietal cortex relates to possible mechanisms underlying the covert attention deficit found in individuals diagnosed with schizophrenia that is discussed later in this chapter.

1.4.1.3. Schizophrenia and the Anti-Saccade

Following the identification of the importance of the frontal lobes in the anti-saccade task, Fukushima et al. (1988) looked at the performance of individuals with a diagnosis of schizophrenia on this task as they were interested in whether any deficits found in schizophrenics were related to atrophy of the frontal cortex. In their study they gave 12 individuals with a diagnosis of schizophrenia and 10 control subjects both a reflexive pro-saccade task and an anti-saccade task. They found that there was not a significant difference in performance between the two groups on the pro-saccade task, but on the anti-saccade task six of the individuals with a diagnosis of schizophrenia showed significantly more errors than the controls. Five out of these six patients showed atrophy of the frontal cortex when given a CT scan, suggesting a link between schizophrenia, frontal cortex atrophy and anti-saccade abnormalities.

Fukushima, Morita, et al. (1990) followed their initial study in by looking into CT scan abnormalities and the performance of individuals diagnosed with schizophrenia alongside patients with affect disorders on the anti-saccade task. They found that on average participants in the schizophrenia group did make significantly more errors than the healthy controls and the affect patients, and although they did not have significantly longer latencies than the healthy controls, they were significantly longer than those with affect disorders. The CT scans were examined for the participants, and those who made the most errors in the schizophrenia group had a significantly higher rate of abnormalities, with 73% showing abnormal scans, whereas those who did not significantly differ from control performance did not have any abnormal scans. The most common abnormality in this group was frontal cortical atrophy, although atrophy of the parietal cortex was also found in some patients. So this finding supports the role of the frontal lobes in anti-saccade performance, and highlights this as possibly underlying the deficit in performance found in relation to schizophrenia. However, many of the schizophrenia participants produced normal CT scans, yet still had a diagnosis of schizophrenia, and some of these individual were among those with the highest number of errors.
In 2006, Tu, Yang, Kuo, Hsieh and Su used fMRI to compare the levels of activation during the anti-saccade task between individuals diagnosed with schizophrenia and healthy control participants. The patient group in this study showed significantly higher error rates than the control group; they also showed less activation in the inferior frontal gyrus, thus supporting the earlier findings of Fukushima et al. (1988; 1990) of a frontal lobe dysfunction. Furthermore, Tu et al. also found reduced activation in the inferior parietal lobe in the individuals with a diagnosis of schizophrenia and that the reduced activation in these two brain regions tended to be lateralised to the left hemisphere. This finding is consistent with Posner, Early, Reiman, Pardo and Dhawan’s (1988) covert cueing study that implied the individuals with a diagnosis of schizophrenia may have a left parietal dysfunction, as their performance on the cueing task was lateralised in performance. However, McDowell et al. (2002) who also found that individuals with schizophrenia showed more errors and reduced frontal lobe activation, but they did not differ on parietal lobe activation compared to the control group, suggesting that frontal lobe dysfunction may be more consistent in this group.

The finding of higher anti-saccade error rates in individuals with a diagnosis of schizophrenia has since been demonstrated consistently across several studies (Allen, Lambert, Attah Johnson, Schmidt, & Nero, 1996; Barton, Pandita, Thakkar, Goff, & Manoach, 2008; Brenner, McDowell, Cadenhead, & Clementz, 2001; Brownstein et al., 2003; Curtis, Calkins, & Iacono, 2001; Franke et al., 2007; Maruff, Danckert, Pantelis, & Currie, 1998; McDowell et al., 2002; N. Smyrnis et al., 2004), despite their preserved ability to execute pro-saccades successfully (Barton et al., 2002; Fukushima, Fukushima, Morita, & Yamashita, 1990; Klein et al., 2000; Levin, Jones, Stark, Merrin, & Holzman, 1982). Another consistent finding in individuals diagnosed with schizophrenia is that they also exhibit longer latencies than the normal population (Barton et al., 2002; Curtis et al., 2001; Franke et al., 2007; Klein et al., 2000; Maruff et al., 1998; Muller, Riedel, Eggert, & Straube, 1999). These increased error rates and latencies in individuals with schizophrenia have been found to be consistent over time; Calkins, Iacono, and Curtis (2003) tested individuals with schizophrenia twice on the anti-saccade task with a 14-18 month gap and found that they were highly consistent for the error and saccade latency measures across the two test times. Finally, this group have shown decreased saccade amplitudes on correctly executed anti-saccade trials.
(Crawford, Haeger, Kennard, Reveley, & Henderson, 1995; S. B. Hutton et al., 1998), but this is a less reported finding.

Several researchers have suggested that individuals diagnosed with schizophrenia have difficulties in the inhibition of saccades and this is why they exhibit higher error rates on the anti-saccade task (Broerse, Crawford, & den Boer, 2001; Samuel B. Hutton & Ettinger, 2006; Kang, Dionisio, & Sponheim, 2011). In order to investigate these individuals’ ability to inhibit reflexive responses, Fukushima, Fukushima, et al. (1990) administered these individuals with both an anti-saccade task as well as a no-saccade task, where they were required to inhibit eye-movements to stimuli appearing in the periphery. They found that participants in the schizophrenia group showed longer latencies and more errors on the anti-saccade task. In the no-saccade task, none of the control participants made eye-movements, and although most of the schizophrenia group managed not to make eye-movements, 30% did make reflexive responses to the stimuli, and furthermore, these individuals made more errors in the anti-saccade task than those who completed the non-saccade task successfully. This implies that at least some errors found in individuals diagnosed with schizophrenia were attributable, in this sample at least, to an inability to inhibit reflexive responses to novel stimuli even when they are not primed to perform an eye-movement. This has been supported by Barton et al. (2008), who found that individuals diagnosed with schizophrenia were poorer at maintaining fixations prior to saccade trials and that these fixation losses were positively related to increased errors on anti-saccade trials. However, general fixation losses on separated fixation trials were higher in individuals with schizophrenia but not related to anti-saccade errors.

In order to look at inhibition and saccades, but without requiring the participants to look away from the target, Brenner et al. (2001) conducted a memory-based prosaccade task. This involved participants fixating on a central stimulus, while another stimulus was then presented briefly to either the left or right while they maintained fixation until the central stimuli appeared when then to look towards the direction the periphery stimuli had appeared. Participants in the schizophrenia group made significantly more eye-movements prior to the central point disappearing indicating a difficulty with inhibiting a response, and they also had longer latencies and shorter amplitudes once the response was made, resembling this group’s anti-saccade performance. Therefore, the longer latencies found here are not unique to anti-saccades, but are evident for other tasks that involve inhibition and working memory.
Barton et al. (2002) looked at the effect on error rates of presenting intermixed anti- and pro-saccade trials to a group of individuals with schizophrenia. The benefits of this include being able to see if individuals can switch attention strategies easily (Hallett & Adams, 1980; Weiler & Heath, 2014). In their experiment individuals with a diagnosis of schizophrenia and comparison subjects were given both blocks of pro and anti-saccade trials presented separately and blocks were they were intermixed pseudo-randomly. In the intermixed blocks there were an even number of pro- and anti-saccade trials, and half the time the trials were the same type as the preceding trial (repeated trials) and the rest of the time the trials involved switching from one response type to the other. The trial type was signalled at the fixation point by either a yellow ‘o’ (pro-saccade) or a blue ‘x’ (anti-saccade) prior to the trial starting. Barton et al. found that the individuals in the schizophrenia group had on average more errors and longer latencies for anti, but not pro-saccade trials. They also found that as a whole the sample made more errors on the task switching trials, but this did not interact with group. The researchers commented that the implications of this were that the anti-saccade deficit found in schizophrenia was independent of the ability to switch tasks, as they were not further impaired by having to task switch on the intermixed task, and their pro-saccade performance was relatively unaffected by being intermixed with anti-saccade trials. However, Barton et al. conducted another study in 2008 where the trials were also intermixed but this time they found that the individuals with schizophrenia had larger error rates for both the anti- and the pro-saccade trials, suggesting that the intermixing did have an interfering effect in this group.

There have also been a few studies that have looked into the effect of anti-psychotic medication and performance on the anti-saccade task. Crawford et al. (1995) and S. B. Hutton et al. (1998) both demonstrated that higher errors on the anti-saccade task are consistent across medicated and non-medicated groups of individuals diagnosed with schizophrenia, with no significant difference in errors between these groups. Burke and Reveley (2002) reported that when participants changed medication from risperidone to typical type anti-psychotics their error rates increased, but error rates were not significantly improved when participants switched medication from atypical anti-psychotic medication to risperidone. Therefore, suggesting that risperidone may benefit some individuals diagnosed with schizophrenia, but it may take a while to cause significant improvements. Studies looking into performance in relation to anti-psychotic medication using normal participants have mixed findings,
with one found no anti-psychotic (risperidone and amisulpride) benefits in comparison with a placebo (Schmechtig et al., 2013), and another study found that risperidone and chlorpromazine (both anti-psychotic) actually significantly increased the number of saccade errors on the anti-saccade tasks compared to a pre-drug performance. However, amisulpride (another anti-psychotic) did not have a significant effect on errors, and none of the anti-psychotic drugs had an effect on the saccade latency measures (Barrett et al., 2004). Thus, perhaps the benefit of some anti-psychotics may be specific to individuals suffering from schizophrenia, or it may be that some even have a detrimental effect.

1.4.1.4. Anti-saccade performance across the Schizophrenia Spectrum

Some researchers have sought to assess whether poorer anti-saccade performance is specific to individuals who have sufficient symptomology to receive a diagnosis of schizophrenia, or whether it may extend to groups who are at risk. In order to do this they have looked at anti-saccade performance in samples such as relatives of those diagnosed with schizophrenia who have genetic vulnerability, therefore giving indications of heritable traits or genetic markers. Another area that researchers have focused on are those with related disorders deemed to be on the schizophrenia spectrum such as Schizotypal Personality Disorder as well as individuals from the normal population with higher numbers of schizotypal traits as these are theoretically related to schizophrenia, as these individuals are therefore deemed to be more vulnerable to the development of schizophrenia (Raine, 1991).

1.4.1.4.1. Anti-saccade Performance in Relatives of Individuals Diagnosed with Schizophrenia

There have been several studies conducted assessing the anti-saccade performance in relatives of individuals diagnosed with schizophrenia, with mixed findings. Some of the studies have found higher error rates in first degree relatives of individuals with schizophrenia (Clementz, McDowell, & Zisook, 1994; Katsanis, Kortenkamp, Iacono, & Grove, 1997) and longer latencies have also been shown in this group (Thaker, Cassady, Adami, Moran, & Ross, 1996) while other studies have found no difference in relatives when compared to control participants overall, but significant correlations with the performance of their relatives in the schizophrenia group (Brownstein et al., 2003; Crawford et al., 1998; McDowell & Clementz, 1997). Thus
suggesting some degree of genetic relation for the anti-saccade performance, but suggesting that it only becomes significantly poorer with schizophrenia itself.

In order to investigate whether there were some subtle deficits in relatives, Curtis et al. (2001) conducted a study looking at anti-saccade performance in individuals diagnosed with schizophrenia and their first degree relatives, where they completed first a normal anti-saccade block and then one that included distractors that preceded the target presentation. They found that the schizophrenia group had more errors than the control group overall, but the relatives only differed when the distractors were presented. The researchers concluded that the distractors increased the ‘inhibition load’ as there were more stimuli that required inhibition of reflexive orienting towards; and this brought out the more subtle deficit in the relative group, which could be missed by a standard anti-saccade task. This puts an emphasis on the need for higher loading tests for less prominent deficits in non-clinical groups. They also suggested that the problem with inhibition may be a candidate for a marker for schizophrenia susceptibility.

1.4.1.4.2. Schizotypy and Anti-saccade performance

In order to investigate anti-saccade performance in the schizophrenia spectrum, Brenner et al. (2001) looked into anti-saccade performance in individuals diagnosed with Schizotypal Personality Disorder (SPD) compared to that of individuals with schizophrenia and healthy controls. They found that those in the SPD group had performance that more closely resembled the healthy control group than the schizophrenia group, as they did not differ from the controls on error rates or latencies. The researchers did however, find that a few of the SPD group did have enough errors to put them outside the range of the control group, thus, indicating that the SPD were more heterogeneous, with individuals who had higher errors perhaps representing individuals who were closer to schizophrenia on the spectrum. It is unfortunately not possible to gain this information from the study as they did not relate specific SPD symptoms to performance, and it would still be expected, if the anti-saccade performance is related to the whole schizophrenia spectrum, that this group would have more errors than controls on this task.

There has also been a body of research examining the relationships between schizotypal traits and performance on the anti-saccade task within the normal population. In a study conducted by O'Driscoll et al. (1998), undergraduate students
who scored highly (2 standard deviations above the mean) on the Perceptual Aberration Scale (PAS), which is a measurement of positive schizotypal traits, were compared on both anti-saccade and smooth pursuit tasks to those who scored within the normal range. They found that the group of higher scoring individuals had significantly more errors in the anti-saccade task than those in the lower scoring group, but the saccade latencies and amplitudes did not differ between the two. As the PAS is primarily a measure of traits relating to the positive symptoms of schizophrenia, the differences found in this study are indicative of relationships to this specific group of symptoms. However, this study also looked at the relationship between scores on the Beck Depression Inventory and anti-saccade errors, finding a positive relationship between the two, suggesting a role for affective disorders or possibly negative symptoms related to schizophrenia. Once depression was controlled for there was still a significant difference between the two groups, indicating that the positive symptoms had a significant effect even when depression was removed as a contributing factor. This study also found a significant difference between the groups on the smooth pursuit task, with individuals in the higher schizotypy group performing more abnormally, this is a finding that has been shown to be consistent with general findings. This was also related to the number of errors on the anti-saccade task, suggesting that these errors are related to more basic eye-movement deficits. This increased number of errors in relation to elevated positive schizotypy scores had been replicated by a number of other researchers (Aichert, Williams, Moller, Kumari, & Ettinger, 2012; Ettinger et al., 2005; Gooding, 1999; Larrison, Ferrante, Briand, & Sereno, 2000; Nikolaos Smyrnis et al., 2003), however, these studies found no significant effects of schizotypy on saccade latencies.

Although the above studies have indicated that there may be a link between positive schizotypy traits and higher numbers of anti-saccade errors, negative traits were not examined individually. Therefore, Holahan and O'Driscoll (2005) conducted a study where they compared individuals who either scored high on the PAS (representing positive traits) or on the Physical Anhedonia Scale (representing negative traits) but not both, along with low scorers on both these scales on both anti-saccade and smooth pursuit tasks. They found that those who scored higher on the PAS made a significantly higher number of errors than those in the low scoring group in the anti-saccade task, whereas those who scored higher on the Physical Anhedonia Scale did not significantly differ from the lower scorers. However, the two groups with the high
schizotypy scores did not significantly differ from each other on errors, suggesting that those with higher number of negative traits overlap with both the normal and the high positive trait scorers. The groups did not differ significantly on saccade latencies for either correct or error responses. The high scorers on the Physical Anhedonia scale were found to have the poorest smooth pursuit performance, followed by those with high PAS scores, with those in the low scoring group with the best performance. These results together suggest that positive schizotypal traits have more of an effect on antisaccade performance, but not poorer eye-movement control overall, than negative traits. Although this study separated out the positive and negative schizotypy traits, by doing so the high scorers become less representative of the schizophrenia spectrum disorder, as although positive symptoms are sometime present alone in individuals diagnosed with schizophrenia, negative symptoms presented alone are less characteristic of schizophrenia, and would not, by definition result in a diagnosis of schizophrenia. Also, contrary to the findings of Holahan and O'Driscoll (2005), Gooding (1999), did find significantly higher numbers of anti-saccade errors in individuals who scored highly on a measure of negative schizotypal traits (the Social Anhedonia Scale) as well as those with higher PAS scores compared to lower scoring controls. This implies that it may depend on the scale that measures the negative traits, or how the researchers have defined these traits, that effects whether a difference is found between high and low scorers.

1.4.1.5. Summary of Anti-saccade Review

In summary, there have been many research studies looking at anti-saccade performance in individuals with a diagnosis of schizophrenia, which have generally shown that these individuals produce more error responses. There is also some evidence for increased latencies, as well as decreased amplitudes in this group. The poorer performance in these individuals has been generally attributed to a deficit in inhibition, although it appears that this may not account for all the errors, suggesting that there may also be a working memory deficit affecting performance.

The evidence in relatives of these individuals seems to indicate that there is some genetic link with performance on the anti-saccade task, with individuals’ error rates being linked to their patient relatives’ scores, and some studies showing longer latencies for the relatives. There is also evidence of a higher error rates in individuals with higher amounts of schizotypal traits, with positive traits particularly implicated.
Some researchers have suggested that harder tasks that require more inhibition may highlight the more subtle deficits in the non-clinical groups.

The anti-saccade task in this thesis is designed to look at both the anti-saccade ability of individuals with a diagnosis of schizophrenia and schizotypy in a student sample tasks that examines both inhibition and the effects of higher working memory demands in these groups.

1.4.2. Covert Attention: the Covert Orienting of Visual Attention Task

1.4.2.1. Posner’s Covert Orienting Task

In order to investigate how individuals applied their attention to different locations within the visual field, Posner (1980) developed a simple attention paradigm designed to examine these covert attention shifts. This paradigm, commonly known as the Covert Orienting of Attention Task (COVAT), in the classic form involves stimuli presented in two locations in the periphery of the visual field to the left and right of a central fixation cross, which participants are required keep their eye fixated on throughout. This, along with rapid presentation of stimuli is in order to assess attention shifts without eye-movements. The requirement is for the attention to be divided between two locations focusing on one when a target was presented. Posner also added a cue to his paradigm that preceded the target which was included in order to draw the participant’s attention to the location it appears in. He then manipulated the cue in the following way: sometimes the cue appeared in the same location as the target (valid cue) requiring the participant only to focus on one location. At other times appeared in the opposite location to the target (invalid cue) thus causing the participants attention to be drawn to the wrong location requiring the participant to switch attention focus from the cue location to the target location. Posner also made the valid cues more prevalent (80% of trials) than the invalid cues (20% of trials) in order to make it beneficial to attend to the cued location, and enhancing any deficits for the invalid trials.

1.4.2.2. Neglect deficits in cueing

Several studies have since been conducted using this paradigm to look at attention in various populations, including individuals with specific brain damage. In 1984, Posner, Walker, Friedrich and Rafal conducted a study looking at individuals with unilateral damage to the (posterior) parietal lobe, either on the right side (normally
associated with attentional neglect syndrome) or the left side. He found that for both
groups their reaction times were slowed more when the target appeared in their
contralesional visual field and was preceded by a cue in the ipsilesional visual field.
Posner et al. suggested that the neglect patients had a problem disengaging their
attention from the visual field ipsilesional side in order to reengage it on the
contralesional side. As neglect is more commonly found in individuals with posterior
right-sided lesions, several researchers have supported the finding that neglect patients
exhibit poorer performance for left sided targets with right lesioned patients,
particularly when following a cue presented on the right (Ladavas, Carletti, & Gori,
1994; Sieroff, Decaix, Chokron, & Bartolomeo, 2007). Thus suggesting that covert
attention shifts are controlled through a neural circuit involving the parietal lobe and
other posterior regions of the brain, which has a right-hemisphere dominance.

1.4.2.3. Schizophrenia and the cueing task

In 1988, Posner and colleagues examined selective attention in individuals with
a diagnosis of schizophrenia using the covert orienting task. They found that the
individuals with a diagnosis of schizophrenia had slower reaction times than the control
group, which indicated a general attention or stimulus processing deficit. Furthermore,
this group also displayed an asymmetrical attention pattern that manifested itself in a
slowed reaction time on invalid trials when the cue appears in the left visual field (and
the target in the right), compared with when the cue side and target side were reversed
(Posner, Early, Reiman, Pardo, & Dhawan, 1988). This attention pattern resembled the
patterns found by Posner in the neglect patients with left-sided parietal lesions,
suggesting that the individuals with a diagnosis of schizophrenia also had problems
disengaging from a left-side cue, and could therefore this could indicate an underlying
parietal lobe deficit. Also, as it is also possible to display neglect symptoms after
sustaining a frontal lobe injury (Husian & Kennard, 1996), and as the frontal lobe has
been implicated as a possible site of dysfunction in schizophrenia (e.g. Liddle
& Morris, 1991) this is also a potential site underlying the attention dysfunction in
individuals with a diagnosis of schizophrenia. However, neglect is more commonly
caused by right-sided lesions, and covert attention is also more associated with the right
hemisphere, it may be that the individuals diagnosed with schizophrenia are actually
exhibiting a right hemisphere bias rather than a left hemisphere deficit. This is
supported by Chapple et al. (2004) who showed that individuals diagnosed with

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schizophrenia showed larger frontal and occipital-parietal regions for the right hemisphere, which represented an exaggerated version of the pattern shown by healthy controls.

Since Posner et al. conducted their study; several others have been conducted looking at individuals with a diagnosis of schizophrenia’ reaction times on the COVAT. A consistent finding was that individuals with schizophrenia were slower at responding to the target overall, however there were more mixed findings for the asymmetry displayed by the schizophrenic group in Posner et al.’s study. Carter, Robertson, Chaderjian, Celaya, and Nordahl (1992), found that chronic patients who were unmedicated displayed the same right visual-field deficit, but others have not found this asymmetrical effect for individuals diagnosed with schizophrenia who were chronic and stable (Gold et al., 1992; Gouzoulis-Mayfrank et al., 2007; Liotti, Dazzi, & Umilta, 1993; Moran, Thaker, Smith, Cassady, & Layne-Gedge, 1992; Strauss, Novakovic, Tien, Bylsma, & Pearlson, 1991), or a relapsed inpatient population (Strauss, Alphs, & Boekamp, 1992), however in the later Strauss et al. study the control group consisted of individuals recovering from cocaine addiction rather than a healthy control group.

Maruff, Hay, Malone, and Currie (1995) noted that in the Posner study the individuals with a diagnosis of schizophrenia were largely un-medicated, and this was also the case with Carter et al. (1992), whereas those in the studies where no asymmetry was found were being treated with typical antipsychotics. They therefore compared medicated and non-medicated schizophrenics and found that those that were not on medication displayed the attentional asymmetries found previously by Posner and those that were on medication did not, thus suggesting that the medication was somehow correcting the neglect-like symptoms shown by the individuals with a diagnosis of schizophrenia. This assertion is supported by a study that found that clozapine, haloperidol and sulpiride (all anti-psychotic medication with both typical and atypical types), reversed asymmetrical behaviour patterns in female rats (Taylor, Smith, & Kirchhoff, 2013).

Sapir and colleagues also conducted a COVAT study in 2007, where they looked at attention patterns in individuals diagnosed with schizophrenia who were receiving depot injection of their antipsychotics. They did this in order to compare performance at low dosage (just prior to the next injection) and high dosage (just following their injection). They found that both groups of patients showed asymmetry patterns, the pre-medication group showed a validity effect (faster responses on valid
over invalid cued trials) for cues in the left-visual field only and the post-medication group had no validity effect for cues in the left-visual field but a large one for the right. Although it appears that this study supports Posner et al. (1988), once again it was found that the difference in the premedication group is actually the down to participants responding faster to valid trials for the left-cued trials than for the right. The researchers therefore argued that the asymmetry actually represented a hypersensitivity to the left visual field, and therefore the right-hemisphere, rather than a left hemisphere deficit. They suggest that this is then reversed by neuroleptic medication, which ends up making the left-hemisphere hyper-responsive (Sapir, Dobrusin, Ben-Bashat, & Henik, 2007). This is supported in a study by Sapir, Henik, Dobrusin, and Hochman (2001) who also found that stably medicated individuals diagnosed with schizophrenia were faster at responding to right-sided valid trials, when compared to valid trials presented on the left.

Bustillo et al. (1997) came up with an alternative explanation for the left-visual field bias, that instead of being affected by medication it may be related to state of schizophrenia at the time of testing, as the individuals who were un-medicated and showing the asymmetry, were generally in an acute stage; those who were medicated were generally in a chronic phase. Bustillo et al. (1997) tested individuals with a diagnosis of schizophrenia who they further categorised into either having a deficit syndrome, characterised by two or more enduring negative symptoms (separate to depression, psychosis, or drug effects), or non-deficit who did not have these symptoms. The non-deficit group had higher scores on the Scale Assessment of Positive Symptoms (SAPS) indicating that they were currently displaying more of the positive symptoms, and the deficit group had higher scores on the Scale Assessment of Negative Symptoms indicating that they were currently exhibiting higher levels of negative symptoms. They found that there were significant effects of group, with the deficit group the slowest to respond, followed by the non-deficit with the normal controls responding fastest. They also found that the deficit group showed an asymmetry with slower performance for right-sided targets, but this was across all cue types (valid, invalid and no-cue). These findings suggest that there are different deficits based on the type of schizophrenia present in the individuals completing the task, with enduring negative symptoms related to a generalized slowing of response, whereas those without the enduring negative symptoms showed the asymmetry but as more generalised one based on the target detection rather than the ability to shift attention.
focus. The fact that the negative symptoms, which are often related to enduring and a harder to treat schizophrenia, were not related to asymmetry but the positive symptoms were, has some support from a study by Robinson et al. (2004) who found that a cerebral asymmetry (assessed by MRI) was related to better outcomes for individuals with first episode schizophrenia. In conclusion, this research indicates that the asymmetry shown in some studies in individuals with a diagnosis of schizophrenia is related to positive symptoms, and that these asymmetries are reduced, and in some cases reversed, by anti-psychotic medication.

1.4.2.4. Voluntary Control of Covert Attention in Schizophrenia

Some researchers have varied the traditional COVAT in order to examine whether individuals with schizophrenia were able to change their strategies to voluntarily control their attention. One way this had been done is through the use of central, or endogenous, cues where instead of the cue being presented in the periphery around one of the target locations, a cue is presented in the central location highlighting either the target location (valid) or non-target location (invalid), often in the form of an arrow pointing left or right. Carter et al. (1992) looked at the ability of individuals with schizophrenia to do both a task with peripheral cues and one with central cues. Although the schizophrenia group showed the left visual-field bias for the peripheral cues, this was not the case for the central cues, where there were slower responses for the left-visual field target over the right-sided targets, which appears to be the opposite pattern. Both cue types had a main effect of validity with faster responses for the validly cued trials. This study seems to imply that the lateralization behind automatic orienting of attention and voluntary orienting are controlled by different underlying mechanisms and follow opposing patterns in schizophrenia.

In another study, Maruff, Pantelis, Danckert, Smith, and Currie (1996) gave individuals with a diagnosis of schizophrenia two versions of the cueing task, the first was a task where all the cues presented were valid cues, therefore directly indicative of target location. In the second task all the cues were invalid, therefore these were also indicative of target location, but the attention has to be purposefully directed away from the cue location in order to benefit, much like a covert attention version of the anti-saccade task. The researchers found that the response times were not different across the two tasks for the control group, but for the schizophrenia group the response times for the invalid task were significantly slower than for the valid cue task. This suggests
that the individuals with schizophrenia were unable to voluntarily orient to the opposing location on the invalid task, therefore switching attention patterns from reflexive to voluntary control, yet the control participants had no problem with this strategy switch. Maruff et al. (1998) supported this finding in another study where they presented a version of the COVAT with the cue validity reversed. This meant that valid cues were now less common (20% of trials) and invalid cues were now the more common trial type (80% of trials). In this anti-cue version of the COVAT it was expected that participants should be able to use the cue information to switch strategies to attend to the un-cued location, as this was now the more likely target location, therefore have faster responses for the invalid trials. Like in their previous study, the control participants were able to do this, and exhibited faster response times for the invalid trials, whereas the schizophrenia group once again persevered with the reflexive orienting and were therefore faster for the valid trials, even though these were now less common. Thus, these two studies indicate that individuals with a diagnosis of schizophrenia show an inability to use cue information to change to voluntary control of attention strategies when control participants are able to achieve this.

This suggests, along with the findings on the anti-saccade task, that problems with inhibition of reflexive orienting, along with attention control are affected in across covert and overt attention in this group.

1.4.2.5. Schizotypy and Cueing

Although there has been comparatively little research published looking into schizotypy and the covert cueing paradigm Larrison et al. (2000) have conducted a study that looked into eye-movement response patterns on a cued task in individuals assessed for positive schizotypal traits (using the Rust Inventory of Schizotypal Cognitions). For this experiment they used a paradigm that was similar to the covert cueing paradigm, as the stimuli involved a target, which was preceded by a cue that was equally likely to be presented as valid or invalid. The difference for this task was that instead of a button press signifying the perception of the target, the participants were required to look towards the target once they perceived it. Larrison et al. found that there was a lateralization in this task based on schizotypy scores, with high-scorers showing a left visual field advantage, where as those with low scores showed a right- visual field advantage. Therefore, although this task does differ from the covert version in terms of the response required, it does indicate that those scoring higher on the
schizotypal measure were behaving more like the un-medicated individuals above. Furthermore, it was related to scores on positive traits which support the theory that this lateralization may be related more to positive, rather than negative, symptoms. The low scorers’ lateralization has actually been replicated within some of the normal observers in the schizophrenia studies and these findings are discussed below.

1.4.3. Lateralization and the Line Bisection Task

The asymmetries shown by individuals with schizophrenia on the covert cueing task are supported by asymmetries shown by this participant group on the line bisection task, where they have been shown to bisect the line significantly to the left (Cavezian et al., 2007; Michel et al., 2007), therefore showing the same left visual field bias but on a simple task. Mennemeier, Vezey, Chatterjee, Rapcsak, and Heilman (1997) have shown that individuals with right hemisphere damage consistently displayed a bias towards the right and control participants consistently bisected towards the left, whereas those with left hemisphere lesions showed larger errors but they not consistently in either direction. This suggests that participants with a diagnosis of schizophrenia are more likely to be showing a stronger dominance of processing for the right hemisphere rather than a left hemisphere deficit. However, some studies have also shown that individuals with a diagnosis of schizophrenia, although exhibiting greater deviation overall, do not show a bias to either side of the visual field (Ozel-Kizil, Baskak, Gunes, Cicek, & Atbasoglu, 2012). Thus, they could still be an underlying left hemisphere deficit.

There is also a hemispheric bias of attention towards the left visual field demonstrated in several other studies in normal individuals, for example in a line bisection task normal participants often display ‘pseudo neglect’ and tend to place their bisections (instructed to be in the middle of the line) towards the left of the middle (Jewell & McCourt, 2000; McCourt & Olafson, 1997; Mennemeier et al., 1997; Scarisbrick, Tweedy, & Kuslansky, 1987). This asymmetry is a consistent finding across paper and pen studies (Michel et al., 2007), computerized studies (Barnett, 2006) and tactile studies (Bowers & Heilman, 1980). The reason this left-ward bias has been termed pseudo-neglect is because it resembles the pattern shown by individuals with unilateral neglect syndrome, who are less accurate when bisecting lines, often showing a bias towards the same side as their lesion (Gottesman et al., 2008; Kim et al., 1999; Lee et al., 2004; Veronelli, Vallar, Marinelli, Primativo, & Arduino, 2014). Unilateral
neglect is most commonly related to right hemisphere damage involving the parietal lobe (Seki et al., 2000), and it is more pronounced for lesions in this area (Park et al., 2006). Therefore, the normal subjects in the above line bisection studies are regarded as displaying a bias that is consistent with the right parietal lobe being associated with the control of covert attention.

There were also asymmetries shown in the COVAT within the non-clinical control groups in the studies described above that were looking at covert attention in individuals with schizophrenia. Several of the researchers found a generalized difference in response time across visual fields with the controls responding faster to trials where targets appeared on the right (Gouzoulis-Mayfrank et al., 2007; Moran et al., 1992; Strauss et al., 1992; Strauss et al., 1991). This was suggested to be related to the use of mostly right-handed individuals, who also used their right-hand to respond, thus through the link of the left-hemisphere responded faster to the right visual field (Strauss et al., 1991). Therefore, the asymmetry in this case is thought to represent the hemispheric control of the response rather than a lateralization of attention control. However, in the Larrison et al. (2000) study where the response was an eye-movement, the lower schizotypal scorers were still lateralized in the same way indicates that it may not only be related to the right-handed responses and may represent some underlying processing instead.

1.4.4. Summary of Covert Attention and Lateralization Review

In summary, individuals diagnosed with schizophrenia have shown some asymmetrical attention patterns, with a left visual field advantage, across both line bisection tasks and the covert cueing task. However, these asymmetries appear to be diminished by anti-psychotic medication and also less apparent in chronic schizophrenia with higher amounts of negative symptoms. Individuals diagnosed with schizophrenia have also been shown to persevere with reflexive attention strategies once the validity of the cues has been altered such that a voluntary control strategy would be more beneficial, whereas healthy controls are able to adapt.

There is a lack of published research into the relationship between performance on the COVAT and schizotypy, which help address the issue of anti-psychotic medication, as the schizotypy can be measured in the normal population who would not be taking this medication. It could also look into the relationships with positive schizotypal symptoms and whether these are related to attention performance. All of
the studies reviewed here also only use response times are a measure of performance, whereas more recent studies have used the ability to judge the presence of a target (presented on 50% of trials) in the cueing task to measure the ability to interpret stimuli across the visual field. This gives a more complete picture as to whether individuals are able interpret information at locations once they are attended to, and also attention strategies can be inferred, thus complimenting the response time measures by giving a more detailed idea of the processes behind covert attention shifts. One method that has been used to look into the performance and strategic measures is the Ideal Observer approach, which applies signal detection theory across multiple locations (two in the case of the cueing task), and it also produces a measure for how much the participants have used the cue information. This analysis is detailed in the next section and will be applied to the analysis of the covert cueing tasks within this thesis.

The aim of the second and third chapters in this thesis is to look at both reflexive and voluntary covert attention patterns across schizophrenia and schizotypy, using a task that requires the participants to judge the presence of a target. This is in order to achieve a more complete picture of the attention shifting abilities of these groups when tested on a covert attention task.

1.5. An Ideal Observer Approach to the Covert Cueing Task

This section of the introduction includes a background and description of the analysis that will be applied later in chapters two and three of this thesis. This begins with a summary of signal detection theory which forms the basis for the ideal observer model then followed by an ideal observer theory overview. This section finishes with the specific version of the ideal observer model that is applied to multiple location cueing tasks, termed the weighted likelihood model, which is applied in the analysis of the current thesis.

1.5.1. Signal Detection Theory

The term Signal Detection Theory (SDT) refers to theoretical explanations of how an observer makes a decision based on ambiguous information, namely deciding whether a signal is presented or not amongst background noise (Green & Swets, 1988). In a standard SDT task the observer is presented with one of two types of trial, either a trial with a signal presentation or one where the noise is presented alone, they are then asked to response either ‘yes’ or ‘no’ as to whether they perceived the signal to be
present or not. There is an underlying idea that the internal response that an individual makes to the stimulus can be represented as a point on a single continuous dimension. The responses fall within one of two distributions based on whether the signal is present (the signal distribution) or absent (the noise distribution). The theory takes into account both external noise that can be manipulated by the experimenter, and internal noise that is created within the observer during the perception and resulting cognitive processing of the stimuli being assessed. The internal noise is responsible for varying the internal response to the same stimuli and thus creating the distributions. Larger values on the continuum are produced when a signal is present, however the two distributions do overlap; and furthermore the harder the observer finds the task the more the distributions overlap. The observer uses the internal response and compares it to a simple decision criterion (λ), they then respond ‘yes’ if it is above this value and ‘no’ if it falls below.

Once an individual responds to repeated presentations of noise and signal trials, the hit rate can be calculated as follows:

\[
Hit Rate = \frac{\text{Number of Yes Responses to Signals}}{\text{Number of Signal Trials}}
\]

Although this gives the performance on the signal trials it gives no indication of how often the observer is responding incorrectly or correctly on the noise presentations, therefore false alarm rates, which describe noise trial performance, can also be computed as follows:

\[
False Alarm Rate = \frac{\text{Number of Yes Responses to Noise}}{\text{Number of Noise Trials}}
\]

The hit rate and false alarm rate can be related back to the signal and noise distributions as they represent the areas under the respective distributions (signal for the hit rates and noise for the false alarm rates), above the criterion.

1.5.1.1. The Equal Variances Gaussian Model

Although the signal and noise internal response distributions can theoretically take on many different shapes, the simplest and most commonly used model in SDT is
one based on the assumption that both the noise and signal distribution are Gaussian (normal) distributions of identical dimensions, only differing on the mean values (an example is shown in Figure 1.1). The reason why this is a useful and commonly used model is that the fixing of the respective variances ($\sigma^2=1$ for both signal and noise distributions) and the noise mean ($\mu_n$) to zero makes it easier to compute the target sensitivity measure ($d'$). This measure represents the difference between the signal and noise distribution means, and with $\mu_n=0$, this means $d'$ represents the mean of the signal distribution. Another reason why this is a useful model is that $\lambda$ and $d'$ can be worked out using the false alarm and hit rates, and from the computation of $z$-scores. The criterion is calculated by equation 1 below. The $d'$ is worked out using the criterion and the hit rate, which gives the area of the signal distribution that is above $\lambda$. Converting the hit rate to a $z$-value will give the distance the criterion is from the mean of the signal distribution ($d'$), therefore $d'$ is worked out by equation 2

$$\lambda = z(1 - \text{False Alarm Rate}) \quad (1)$$
$$d' = \lambda + z(\text{hit rate}) \quad (2)$$

The studies within this thesis that use a yes/no signal detection version of the covert cueing task use analysis based on SDT described above. Although the Equal Variance Gaussian Model forms a basis for analysis in these studies, the one previously described is does not adequately take into account the possibility of a signal appearing at multiple locations. Therefore, analysis for these studies is based on work with Ideal Observer Models, and further parameters are introduced to account for the possibility of the target appearing at two locations, as well as measures for the utilization of the cue information.
1.5.2. Ideal Observer and Weighted Likelihood Models of Attention

The term Ideal Observer refers to the best performance possible under predefined conditions (Green & Swets, 1988). Ideal Observers are mathematically derived from known information about signal parameters, and these are then used to compare to real observers performance often to test theories. If a parameter makes the Ideal Observer model performance decrease then it should follow that real observers performance should decrease also.

In relation to the COVAT a body of work has been developed looking into the ideal observer’s performance, pioneered by Eckstien, Shimozaki and Abbey, based on previous work on visual search task (e.g. Eckstein, 1998). Initially the researchers set out to test different theories underlying the performance on the COVAT, developing their Ideal Observer model as a parallel processing model that weighted information differently at the cued and non-cued locations, which they termed the ‘weighted likelihood model’ (Eckstein, Shimozaki, & Abbey, 2002). They were challenging the traditional models that suggested a serial processing of attention (e.g. Posner, 1980).

The model developed by Eckstein et al. (2002) was based on Bayesian probability theory, where observers evaluate internal responses to each location as to how likely that internal response would be based on the signal being present at the location being responded to. These probabilities are then weighted, based on the cue validity percentage in the case of the ideal observer, with the cue location weighted at the cue validity and the uncued location weighted at 100-cue validity percentage, and summed. This becomes the numerator of the likelihood ratio (see equation 3). The denominator is the probability of the response given there is no signal present at either location.

\[
\text{Likelihood Ratio} \left( L_{s/n} \right) = \frac{w_c L(x_c, x_{uc} \mid s_c, n_{uc}) + w_u L(x_c, x_{uc} \mid n_c, s_{uc})}{L(x_c, x_{uc} \mid n_c, n_{uc})}
\]  

(3)

This likelihood ratio is then compared to the decision criterion (\(\lambda\)); if the value is higher than the criterion the decision reached is that a signal has been perceived; if it is lower then the decision will be that no signal was detected.
Taken from S. S. Shimozaki, Eckstein, and Abbey (2003); this model uses the assumption that the noise and signal distributions are Gaussian; this can be substituted into the weighted likelihood ratio, shown in equation 4.

\[
L_{s/n} = \frac{w_c e^{-\frac{1}{2}(x_c-d')^2 + x_{uc}^2)} + w_{uc} e^{-\frac{1}{2}(x_{uc}-d')^2 + x_{uc}^2}}{e^{\frac{1}{2}(x_c^2 + x_{uc}^2)}}
\] (4)

The d’ used here is the mean of the signal distribution (as shown above in the equal gaussian model), with the mean of the noise distribution being equal to 0 and the variance for both are equal to 1. The valid hit rate, invalid hit rate and false alarm rates can be expressed as probability functions shown in equations 5, 6 and 7.

\[
H_v = \text{valid hit rate} = p\left(\log\left(\frac{L_{s}}{n}\right) > \lambda \mid s_c n_{uc}\right)
\] (5)

\[
H_i = \text{invalid hit rate} = p\left(\log\left(\frac{L_{s}}{n}\right) > \lambda \mid n_c s_{uc}\right)
\] (6)

\[
FA = \text{false alarm rate} = p\left(\log\left(\frac{L_{s}}{n}\right) > \lambda \mid n_c n_{uc}\right)
\] (7)

In this instance, Shimozaki et al. used the likelihood ratio to estimate the ideal observer’s valid and invalid hit rates, and also the false alarm rates. They did this by using fixed cue weightings of the cue validity values, a optimal (unbiased) criterion of 0, and replacing the d’ score with the signal to noise ratio (SNR), which assumes no internal noise (as is appropriate for the ideal observer). The SNR was then systematically varied and the valid and invalid hit rates, and the false alarm rates were calculated and graphed in order to be compared to the participants’ actual data. In order to fit the participants’ data to the model Shimozaki et al. initially ran Monte Carlo simulations of 10,000 systematically for each combination of d’, \(w_c\), \(w_{uc}\), and \(\lambda\). This simulations were run separately for the case of the signal being at the cued location, at the uncued location and no signal being present in order to generate an valid hit rate, invalid hit rate and false alarm rate for each combination of variables. These were then compared for goodness of fit to the participants’ actual valid hit rate, invalid hit rate and false alarm rates.

Shimozaki et al. found that, when compared to fits of a weighted linear model and an attentional switching model, the fits from the weighted likelihood model were
the closest to the participants’ data. This has been supported by studies conducted by Eckstein et al. (2002) and S. S. Shimozaki (2010) who found that the likelihood model was a better fit to their participants’ data than serial processing models. S. S. Shimozaki, Schoonveld, and Eckstein (2012) also found the weighted likelihood model was a good fit to the data, predicting both cueing effects and set size effects.

1.5.3. The Weighted Likelihood model in this Thesis

In this particular study, we use the simulations involved in the ideal observer analysis to approximate weights, criteria and d’ (target sensitivity). The way this is conducted is by systematically varying the weights, criteria and d’ in nested for loops, within bounded limits (0-100 for weights; -3.5 – 16.5 for the criterion 0-4.5 for d’). This is in order to produce Monte Carlo simulations for each combination of these measures. The Monte Carlo simulations, like those above, are conducted by repeatedly entering the specific combination of the cued and uncued weights and d’ into the likelihood ratio, along with randomly sampled data from the (Gaussian) noise distribution (μ=0; σ=1) and/or the signal distribution (μ=d’; σ=1) in order to simulate the occurrence of internal noise. This likelihood ratio is then compared to the criterion (which is also systematically varied) in order to indicate for each trial whether the signal is ‘detected’ or not. Within each combination of weights, criterion and d’, the simulations were run 150000 times, with 50000 of them simulating trials with a signal at the cued location, 5000 trials with a signal at the uncued location and 5000 trials with no signal simulations. Once these simulations are completed they created approximated hit rates for valid and invalid cued trials and false alarm rates. In order to calculate the weights, criterion and d’ for each participant, the hit rates for the cued and uncued locations and false alarm rates are calculated. These were then statistically compared (using chi-square) to the combination of valid and invalid hit rates, and false alarm rates for each of the combinations of weights, criterion and d’ created by the Monte Carlo simulations. The closest fit to the data (where chi-square is closest to 0) is then used for the measures. This is done for each participant.

1.6. Research Aims

This thesis was designed to investigate whether individuals with a diagnosis of schizophrenia exhibit consistent selective attention deficits across reflexive and voluntary covert and overt attention. This was done through research based on the
cueing paradigm, and the anti-saccade paradigm and whether this extends into the schizophrenia spectrum. It is also specifically designed to measure the ability, in relation to schizophrenia, to employ task relevant strategies across the attention measures.

In chapter two of this thesis the performance of individuals with schizophrenia as well as in relation to schizotypal traits in a student sample was examined on a target judgement version of the COVAT, where the valid trials will be the dominant trial type. In the third chapter of this thesis the student sample and schizophrenia sample have their voluntary control of attention assessed by a target judgement version of the COVAT where the invalid trials will be the dominant trial type. In particular, these chapters investigate how participants select stimuli to attend to within the visual field, using the ideal observer analysis on a yes/no target detection version of the cueing task task. This has not been looked at previously in this group, and it should add to the current literature by providing performance (d’ and hit rate) and strategy measures (cue weighting and criterion) to go with the response time measure reported previously, thus, giving more insight into signal processing abilities in this group.

Finally, in the last chapter a student sample and individuals diagnosed with schizophrenia will be given three tasks; the first task is designed to assess their ability to maintain fixation while responding to stimuli presented in the periphery, therefore their basic inhibition of reflexive orienting. The second task consists of a block each of pro- and anti-saccade trials in order to assess their basic ability on these tasks. The final task involves intermixing the pro- and anti-saccade trials across two task types, where the pro-saccades will be more likely on one task, and anti-saccades on the other, thus mirroring the COVAT proportions of cue types. The trial type will be signaled by the colour of the circle that is presented in the periphery. This task involves inhibition of eye-movements, then covert attention shifts, as participants are required to maintain fixation in order to judge the colour of the circle, followed by an eye-movement in the correct direction.
Chapter Two

An Investigation into Performance Related to Schizotypy and Schizophrenia on a Covert Orienting of Attention Task

2.1. Introduction

In 1988, Posner, Early, Reiman, Pardo and Dhawan examined selective attention in individuals with a diagnosis of schizophrenia using the covert orienting of attention task (COVAT). In this task participants were asked to respond when they saw a predefined target; this target is preceded by a cue that is presented in the same location as the target 80% of the time (valid cue) and in the opposite location 20% of the time (invalid cue). Posner et al. (1988) found that not only did the schizophrenic participants have slower response times to the target than the control group, but they also displayed an asymmetrical attention pattern. This manifested itself in a slowed reaction time on invalid trials when the cue appears in the left visual field (and the target in the right), compared with when the cue side and target sides were reversed. This attention pattern resembled the patterns found by Posner, Walker, Friedrich, and Rafal (1984) in the neglect patients with left-sided parietal lesions who also showed a left visual field bias on this same task, and they postulated that this same region may be involved in the asymmetry in the individuals with schizophrenia. Others have suggested that it may be related to a larger dominance of the right hemisphere parietal lobe rather than a left-hemisphere deficit (Sapir et al., 2007).

Since the Posner et al. (1988) study, several others have been conducted looking at cueing and the reaction times of individuals diagnosed with schizophrenia, with some also demonstrating a left-visual field advantage (Carter et al., 1992; Sapir et al., 2007; Sapir et al., 2001), whilst others have not found this asymmetrical effect (Gold et al., 1992; Liotti et al., 1993; Strauss et al., 1992; Strauss et al., 1991). In 1995, Maruff, Hay, Malone and Currie noted that in the Posner study the individuals with a diagnosis of schizophrenia were largely un-medicated, whereas those in the studies where no asymmetry was found were being treated with antipsychotics. They therefore compared medicated and non-medicated individuals with schizophrenia and found that those that were not on medication displayed attentional asymmetries, and those that were on medication did not; thus suggesting that the medication was somehow
correcting the neglect-like symptoms shown by the individuals with a diagnosis of schizophrenia. The potential role of anti-psychotics has since been replicated by Sapir, Dobrusin, Ben-Bashat and Henik (2007) who found a asymmetry prior to a monthly anti-psychotic depot injections when dose was low, but this was not present immediately after the dose was administered. Another suggestion is that the asymmetries are more related to acute psychotic phases and are absent in individuals with chronic schizophrenia that are often used as participants in these studies (Bustillo et al., 1997).

In order to investigate asymmetries in schizophrenia without the confounding factor of anti-psychotic medication, studies involving individuals from the non-clinical population assessed for schizotypal traits are potentially informative. There aren’t published studies conducted on the COVAT using schizotypal traits, but Larrison et al. (2000) did show some lateralization effects in individuals with higher schizotypal scores; who showed less impairment on the invalid cues for the left visual field targets. However, the response to the target in this particular study involved making an eye-movement towards the target, and is therefore measuring an overt response following covert attention shifts, rather than just the covert attention shifts alone, making it less comparable to the previous studies focusing solely on covert attention.

This hemispheric bias of attention towards the left visual field is also demonstrated to a lesser degree in normal individuals; for example normal participants tend to deviate to the left on the line bisection task (where participants are instructed to bisect or find the middle of a line) therefore displaying ‘pseudo neglect’ (Jewell & McCourt, 2000; McCourt & Olafson, 1997; Mennemeier et al., 1997; Scarisbrick et al., 1987); representing the right parietal dominance for selective attention processing. Individuals with schizophrenia have also been shown to deviate to the left on the same task in some studies (Cavezian et al., 2007; Michel et al., 2007; Tian et al., 2011), however, others have again not replicated this asymmetry (Ozel-Kizil et al., 2012).

Previous studies using the COVAT to look into attention deficits in individuals with a diagnosis of schizophrenia have focused on reaction times to trials where the target is always present; they therefore have not examined the ability in these individuals to make a judgement once they have attended to a location, nor have they looked into the attention strategies that these individuals employ in covert attention shifts. The current study presented the target on half the trials in a COVAT task, with participants being required to indicate whether or not they perceived it. Adding this
decision component makes it possible to investigate whether, in relation to schizophrenia, participants are not only slower, but also less able to interpret stimuli when their attention is divided across two visual fields, as well as looking into their strategies on this task. The first experiment in this chapter looks into the relationship between schizotypy scores and scores on the SPQ and performance on the decision version of the COVAT. The second experiment looks into the same task type but comparing the performance between a group of individuals diagnosed with schizophrenia and a community comparison group.

It is predicted that there will be a negative relationship between the performance variables and the schizotypy measures, and a positive relationship between schizotypy measures and response times, as higher scorers are expected to perform worse on the task. For the schizophrenia group it is expected that they will be poorer at target discrimination and also be slower at responding. More specifically, it is predicted that individuals with higher schizotypy scores, as well as those with schizophrenia, will perform worse for right-sided target trials in the invalid condition than for left sided target trials, across the response time and target discrimination measures. The relationship between the schizophrenia spectrum and the strategic measures of cue weighting (assessment of cue utilization) and criterion (bias of response type) will also be explored. This is in order to investigate whether there were abnormal strategies underlying poorer performance in relation to the schizophrenia spectrum.

2.2. Experiment One

2.2.1. Method

2.2.1.1. Participants

Fifty-two students participated in this study, consisting of 7 males and 45 females. The sample had an average age of 19.4 ($M; SD=1.50$). All the participants were psychology undergraduate students from the University of Leicester who took part in order to earn credits as part of their course. All participants had a high level of English required for their degree and they all had either normal or corrected to normal vision.
2.2.1.2. Design

There were two data files; one for all the trials and the other was for the signal trials, this was in order to look at the effect of cue types and make it easier to compare to previous research. The independent variables for the all trial analysis were target contrast (2 levels: low peak contrast of 31.25% and high peak contrast of 46.88%), cue location (3 levels: left cue/right cue/double (neutral) cue), target presence (present/absent) and for the signal trials there were also target location (left or right) and cue type (valid/invalid/double cue) as independent variables. Each of the independent variables’ level were equally distributed across trials except for the cue type which were distributed across signal trials as follows; neutral cues 33%, valid cues 47% and invalid cues 20% (the cue validity was 70%). The dependent variables for all trial analyses were target sensitivity (d’), criterion (λ), cue weighting (weights) and response times (see introduction for the details of how d’, weights and λ were calculated). For the signal trial analysis the dependent variables were hit rate and response times.

2.2.1.3. Materials

The measure used to assess schizotypy in this study was Raine’s Schizotypal Personality Questionnaire (SPQ), a 74-item dichotomous (yes/no) scale that has been designed to measure schizotypal traits within the non-clinical population. The scale has nine subscales, representing the nine criteria traits for Schizotypal Personality Disorder as listed in the DSM-III-R (APA, 1987), and three factors: Cognitive-Perceptual, Interpersonal and Disorganized (Raine et al., 1994), which are theorised to represent the positive, negative and disorganized symptom groups found in schizophrenia (Liddle, 1987). The internal consistency reported in Raine’s (1991) paper was high (Cronbach’s α=.91) as was the test-retest reliability (Pearson’s r=.82). The SPQ was administered as a paper and pen test. See Appendix C for a breakdown of the SPQ and its subscales and factors, as well as the measure itself.

The cueing task was written on IDL6.3 and was presented on a View Sonic P227f monitor (39.1 cm x 29.3 cm, 1280 x 960 pixels, 0.3052 mm/pixel) at 88 HZ. The monitor was controlled by a Bits++ graphics card (Cambridge Research Systems). The mean luminance of the display was 81.2 cd/m². The programme produced blocks of trials that were consistent for contrast level within each block. Throughout the duration of the task a fixation cross measuring 0.5° x 0.5° was present in the centre of
the screen. During the trial cue, target and non-target stimuli (pedestal) appeared 10° to the left and right of the target location. The cue consisted of a black 3.0°x3.0° box; while the target and non-target stimuli consisted of a 2D Gaussian with σ=14.7 minutes. The non-target pedestal had a peak contrast of 15.63%, while the target varied across two contrast levels of 31.25% (low-contrast trials) and 46.88% (high-contrast trials). These stimuli are shown below in Figure 2.2.

![Figure 2.2](image)

**Figure 2.2.** Examples of stimuli used in experiment one presented in trial presentation order

### 2.2.1.4. Procedure

Each participant was tested individually in one session, completing the attention measure in two blocks, with the SPQ being completed in between. During the attention task participants sat 50cm from the computer screen and rested their head on a chin rest to ensure that their eyes were kept in a fixed position throughout the task. In a typical trial, participants began by pressing the space bar while fixating on the cross; after one second the cue would appear, either to left, to the right or both sides of the fixation cross depending on the cue type. The cue was displayed for 150ms, followed immediately by the presentation of a target and pedestal or double pedestal presentation for 60ms across the left and right locations. Participants responded by pressing one of two defined buttons based on whether they perceived the target or not regardless of location.
Prior to the task participants were informed of the cue types and along with their respective frequencies as well as how frequently the target would appear. Participants were requested to respond as quickly and accurately as possible; whilst looking at the fixation cross throughout. Following the instructions, participants completed a ‘practice block’ where a simple version of the experiment was presented and the responses were not reported; this consisted of 60 trials. Participants then began the recorded task; this consisted of two blocks of 90 trials in each session. There was one block for each of the two contrast conditions. The other variables (target presence, cue type, cue location and target location) were varied randomly throughout the blocks. In between the two sessions the participants were given the SPQ as a paper and pen measure.

2.2.1.5. Data Analysis

The participants’ scores on the Schizotypal Personality Questionnaire were calculated by scoring one for every ‘yes’ response and no score for each ‘no’ response. Based on this total, subscale and factor scores were created for each participant (see Appendix C for a breakdown of the factor and subscale scoring).

Initially the responses from the task were screened and all trials where a button other than the two defined response buttons was pressed were excluded; trial data were also excluded if the response time was faster than 100ms (to exclude anticipatory responses) or slower than three seconds (as the participants were deemed to have missed the target presentation) this resulted in a proportion of .013 trials being excluded.

The valid, invalid and neutral hit rates and false alarm rates were converted into target sensitivity (d’), cue weighting and criterion (λ) based on a chi-squared fit to the Monte Carlo simulation models outlined in the introduction (see also:(Eckstein et al., 2002; S. S. Shimozaki, 2010; S. S. Shimozaki et al., 2012) for a description of this analysis). For the signal only data set average hit rates (no. correct response to target/no. target present trials) and average response times were calculated to represent each of the factor levels. For each of these datasets a MANOVA was performed in order to examine the effects of the repeated measures factors. Following this four MANCOVAs were performed with a different aspect of the SPQ as a covariate in each (total score, and cognitive-perceptual, interpersonal and disorganised subscales). Post hoc test consisted of pairwise comparison t-tests, with a multiple comparison
adjustment of Hochberg’s step-up method (Hochberg, 1988), and correlation analysis (for the covariate measures) where conducted where significant interactions were found.

2.2.2. Results and Discussion

Initially mean and standard deviation scores for the total and three factor SPQ scores were calculated for the sample and these are shown in Table 2.1. Histograms showing the distribution of these scores across the sample are shown below in Figure 2.3. Overall the sample had a low mean that would be expected for the normal population. The distributions for the SPQ and its factors are roughly negatively skewed, although the disorganized factor is the most heavily skewed. These distribution fit the theoretical negatively skewed distribution of a schizophrenia continuum proposed by Van Os et al. (1999), who suggested that traits related to schizophrenia are going to exist in small amounts in the majority of the population, with a small number of individuals displaying high amounts of these traits. This sample also had no particularly high scorers, as no-one scored above 50.
Table 2.1. Descriptive Statistics for Schizotypal Personality Questionnaire Total and Factor Scores

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Score</td>
<td>19.54</td>
<td>11.65</td>
</tr>
<tr>
<td>Cognitive Perceptual Factor</td>
<td>7.29</td>
<td>5.51</td>
</tr>
<tr>
<td>Interpersonal Factor</td>
<td>9.54</td>
<td>6.40</td>
</tr>
<tr>
<td>Disorganized Factor</td>
<td>4.69</td>
<td>3.50</td>
</tr>
</tbody>
</table>

2.2.2.1. Effects of Within-Participant Factors: Overall Attention Performance

The MANOVA revealed main effects for target contrast and cue type for the all trial analysis displayed in Table 2.2, and main effects for target contrast and target side for the signal only trials displayed in Table 2.3. Generally performance for both the all trial analysis and signal only trial analysis, was shown to be better for the higher target contrast condition than the lower target contrast condition, as shown by higher $d'$ and
hit rates and also faster responses for the higher contrast level. This is consistent with general findings of better performance for higher contrast, which has been proposed to follow higher neuronal activity to more salient stimuli (Pooresmaeili, Poort, Thiele, & Roelfsema, 2010). The difference in criterion across the two levels was less expected as it signified that in the higher contrast condition individuals were more biased to respond that they had perceived the target. This could be partly a speed-accuracy trade-off, as participants may have been trying to respond more rapidly and therefore were more likely to press the button under their dominant index finger in an anticipatory manner.

The main effect of cue location revealed that participants were significantly faster in the neutral condition than both the left ($MD=.046; p<.0005$) and right ($MD=.062; p<.0005$) cue conditions, which is shown in Figure 2.4. For the criterion there were significant differences again between the neutral trials and left cues ($MD=1.63; p<.0005$) and also the neutral trials and right cues ($MD=1.82; p<.0005$), also shown in Figure 2.4. This indicated that the participants were more biased to respond having seen the target for the single cued trials than for the neutral cued trials. Post hoc tests revealed no individually significant difference between the weightings for the different cue locations. These main effects appear to imply that the double cue was processed significantly differently to single cues as participants responded faster, and participants were more likely to respond ‘target absent’ for the double cue and ‘target present’ for the single cue. The greater bias for the single, over the cued location, may represent the focusing of attention in one location, rather than over the two locations, lead to the target being incorrectly perceived where the cue was presented, leading to this bias for signal present responses for these trial types.

![Figure 2.4](image-url) The means and standard errors for the different cue locations for the response time (left) and criterion (right) measures.
The main effect of target side, significant for response time only, revealed that individuals were faster on the trials where the target appeared on the left than the trials with a right sided target. This finding is the opposite finding in the normal controls in previous studies where the normal individuals were shown to have a right-field advantage (Gouzoulis-Mayfrank et al., 2007; Moran et al., 1992; Strauss et al., 1992; Strauss et al., 1991) however, it is more consistent with the asymmetries shown on the line bisection task (Jewell & McCourt, 2000) and the role of the right-hemisphere parietal lobe in processing of attention (Posner & Petersen, 1990).

Figure 2.5. Means and standard errors for effect of the target location variable on the response time measure.
Table 2.2. *Table of main effects from multivariate analysis of variance for all trials*

<table>
<thead>
<tr>
<th>Contrast</th>
<th>Cue Location</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>High M(SE)</th>
<th>Low M(SE)</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>Neutral M(SE)</th>
<th>Left Cue M(SE)</th>
<th>Right Cue M(SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td></td>
<td>4.48</td>
<td>20.11</td>
<td>.63</td>
<td>8,200</td>
<td>17.81</td>
<td>8,200</td>
<td>17.81</td>
<td>.42</td>
<td>623(20)</td>
<td>669(20)</td>
<td>685(20)</td>
</tr>
<tr>
<td>Response Time</td>
<td></td>
<td>1.51</td>
<td>9.57</td>
<td>.16</td>
<td>64(20)</td>
<td>.68(.02)</td>
<td>2,102</td>
<td>33.58</td>
<td>.40</td>
<td>60(.17)</td>
<td>-1.03(.13)</td>
<td>-1.22(.13)</td>
</tr>
<tr>
<td>Criterion</td>
<td></td>
<td>1.51</td>
<td>21.40</td>
<td>.30</td>
<td>-9(13)</td>
<td>-21(.10)</td>
<td>2,102</td>
<td>50.38</td>
<td>.50</td>
<td>6(17)</td>
<td>-1.03(.13)</td>
<td>-1.22(.13)</td>
</tr>
<tr>
<td>Weights</td>
<td></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>47(2.83)</td>
<td>43.12(2.57)</td>
<td>2,102</td>
<td>3.70</td>
<td>.07</td>
<td>49.07(1.03)</td>
<td>37.49(4.37)</td>
<td>49.09(4.15)</td>
</tr>
<tr>
<td>Dprime</td>
<td></td>
<td>1.51</td>
<td>70.85</td>
<td>.58</td>
<td>2.83(.16)</td>
<td>1.87(.11)</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>2.28(.14)</td>
<td>2.33(.13)</td>
<td>2.44(.13)</td>
</tr>
</tbody>
</table>

*Pillai’s Trace Reported*
For all significant results $p<.01$ except *significant to $p<.05$.

Table 2.3. *Table of main effects from multivariate analysis of variance for signal only trials*

<table>
<thead>
<tr>
<th>Contrast</th>
<th>Target Side</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>High M(SE)</th>
<th>Low M(SE)</th>
<th>df</th>
<th>F</th>
<th>$\eta^2$</th>
<th>Left M(SE)</th>
<th>Right M(SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td></td>
<td>2.50</td>
<td>35.81</td>
<td>.589</td>
<td>2.50</td>
<td>8.13</td>
<td>.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response Time</td>
<td></td>
<td>1.51</td>
<td>68.65</td>
<td>.57</td>
<td>608(17)</td>
<td>669(23)</td>
<td>1.51</td>
<td>13.74</td>
<td>.21</td>
<td>620(18)</td>
<td>657(20)</td>
</tr>
<tr>
<td>Hit Rate</td>
<td></td>
<td>1.51</td>
<td>15.28</td>
<td>.23</td>
<td>.87(.02)</td>
<td>.75(.02)</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>.82(.01)</td>
<td>.80(.02)</td>
</tr>
</tbody>
</table>

*Pillai’s Trace Reported*
For all significant results $p<.01$ except *significant to $p<.05$.
There was no main effect of cue type, and therefore no clear cueing effects for this sample. This was supported by the findings from the analysis of the weighting measure where one sample t-tests were conducted for the cue weighting of the single cues, these were found to significantly differ from the optimal weighting of 70, which is based on the cue validity \((t(51)=-8.19; p≤.0005)\). The single cues were therefore then compared to 50 (equal weighting), along with the double neutral cue (which was expected to be weighted equally). The neutral cue did not significantly differ from 50 \((t(51)=-.896; p=.375)\) indicating equal weighting, but the single cues did differ significantly from 50 \((t(51)=-2.06; p=.045)\). This difference, however, was actually in the direction opposite to optimal weight, or less than 50, specifically for the left cues. As the finding of a cue effect is a very consistent over many studies (Larrison et al., 2000; Maruff et al., 1995; Moran et al., 1992; Posner et al., 1988; S. S. Shimozaki et al., 2003; Strauss et al., 1992; Strauss et al., 1991), it was expected to be evident in this sample. It is possible that the neutral ‘double cue’ interfered with the cueing effect, as the analysis for these trials appear to show a different behaviour on these trials, as shown by shorter response times and a different strategy employed.

For the signal only trials there was a significant interaction between cue type and target contrast \((F(4,204)=2.89; p=.024; \eta^2=.054)\) which was shown to be significant for hit rate individually \((F(2,102)=5.34; p=.01; \eta^2=.10)\); shown in Figure 2.6. Further analysis indicated that, although there was a significant difference between difficulty levels for each cue type, the differences between contrast levels were significantly bigger for the neutral condition than for the invalid condition \((MD =.086; p=.012)\). There were no significant differences across cue types for either of the contrast levels. This interaction is highlighting the main effect of contrast, but it also seems to suggest that for the neutral trials the lower contrast level had a larger effect of difficulty in relation to the high contrast level hit rate.
The other significant interaction was between cue type and target side for the hit rate measure ($F(2,51)=3.21; p=.044; \eta^2=.059$). The post hoc test revealed that for the hit rate interaction (shown in Figure 2.7) there was only a significant difference between left and right cue sides for the valid cue type ($t(51)=3.09; p=.003$), indicating significantly higher hit rates for the left valid cued. This is consistent with the left-visual field advantage shown for the response time measure, indicating that there is within-sample consistency for this across the two performance measures on the signal trial analysis. However, there was no difference for the invalid trials, suggesting this visual field advantage was not related to the ability to switch attention between the two sides.

Figure 2.6. Means and standards errors showing the interaction between the Target Contrast and Cue Type variables for the Hit Rate measure

![Figure 2.6](image)

Figure 2.7. Means and standard errors for the interaction between cue type and target side for the hit rate measure

![Figure 2.7](image)
2.2.2.2. Effects of Schizotypal Personality Questionnaire Measures

In the signal trials analysis there were several significant interactions involving scores on the SPQ. The first significant interaction was between the total score on the SPQ and the target contrast factor on the hit rate measure ($F(1,50)=4.87; p=.032$ $\eta^2=.089$). This was also consistent for the Cognitive Perceptual factor ($F(1,50)=6.30; p=.015; \eta^2=.112$). Representations of these interactions are shown in Figure 2.8. It appears that for the total SPQ scores there were no significant relationships with hit rates on either the high or low contrast condition. The cognitive-perceptual scale was found to have a significant negative relationship with the hit rate measure for the low target contrast condition ($r(52)=-.281; p=.043$). There were also significant positive relationships found between the contrast difference (high contrast hit rate – low contrast hit rate) and the SPQ measures (Total: $r(52)=.298; p=.032$; Cognitive-perceptual: $r(52)=.334; p=.015$). These findings indicate that in the condition where the target was harder to discriminate the individuals who score lower on the SPQ had higher hit rates, and those that scored higher were poorer on this task. In the high contrast condition this difference evened out probably due to participants reaching a ceiling level. Therefore there was a relationship in the expected direction between the ability to correctly identify the target positive schizotypy trait scores when the task was difficult enough. However, this was only significant for trials when the target was present and wasn’t related to target sensitivity overall.
Another significant interaction indicated through the MANCOVA analysis was between the target contrast and cue type factors and the total score on the SPQ for the hit rate measure ($F(2,49)=4.307; p=.016; \eta^2=.079$). This interaction is also significant for the Cognitive-Perceptual ($F(2,49)=3.589; p=.031; \eta^2=.067$) and Disorganised factors ($F(2,49)=6.703; p=.002; \eta^2=.118$), shown in Error! Reference source not found.. Post hoc correlational analysis revealed that all three SPQ scores were significantly, and negatively, related to the hit rate on the low contrast condition but for neutral trials only (Total: $r=-.366; p=.008$; Cognitive-Perceptual: $r=-.400; p=.003$; Disorganised: $r=-.302; p=.029$). The significant relationships suggest that individuals with higher SPQ scores had lower hit rate scores in the lower contrast condition for the neutral trials.

The total SPQ, cognitive-perceptual and disorganized scores were also significantly related to the difference between contrast levels (high contrast hit rate-low contrast hit rate) for the neutral trials (Total: $r=.400; p=.003$; cognitive-perceptual: $r=.413; p=.023$; disorganised $r=.374; p=.006$) and the disorganised factor was also significantly related to the difference between contrast levels for the valid trials ($r=.326; p=.018$). This relationship suggested that the lower contrast level detrimentally affected the hit rate levels more for the higher disorganized factor scorers on valid as well as neutral trials.

Figure 2.8. Relationships between hit rates for high and low contrast conditions and the total SPQ score (left) and the Cognitive-perceptual factor (right).
2.3. Experiment Two

2.3.1. Method

2.3.1.1. Participants

Twenty-six participants took part in this study; 13 participants made up the schizophrenic group and 13 made up the comparison group. The demographics for these groups, along with the Wechsler Adult Intelligence Scores and Brief Psychiatric Rating Scale scores for the schizophrenic group, are displayed in Table 2.4 below. All the participants in the schizophrenic group were recruited through Leicestershire Partnership Trust outpatient services, either being directly approached by healthcare
professionals or responding to posters displayed in the service centres. All participants had been diagnosed according to IDC-10 classification for schizophrenia, with four participants with a sub-category diagnosis of paranoid schizophrenia. Two of the participants had recently had their diagnosis changed to schizoaffective disorder, one of these while participating in the study. Two of the participants had co-diagnoses of depressive disorders. All the participants in this group were taking anti-psychotic medication; three were taking traditional antipsychotics (2 Flupentixol and 1 Haloperidol) and 10 were taking atypical antipsychotics (4 Clozapine, 4 Risperidone and 2 Aripiprazole) as their primary medication. Nine of the participants were taking anti-depressant medication; four were taking medication for the side effects of the antipsychotics and one participant was taking lithium as a mood stabiliser (see Appendix A for detailed medication profiles of the participants in the schizophrenia group). The exclusion criteria for this group included a history of neurological or ophthalmological disease, head injuries or ECT in the last 10 years, no past substance dependency and no current substance abuse, and finally absence of learning disability. Participants were required to speak English as their main language and to have a normal or corrected to normal vision.

The 13 control participants were recruited from the community through advertisements displayed in public places, such as adult education centres and the university, and through previous participation in other university studies. The extra exclusion criteria for this group consisted of any history of psychiatric illness and familial history of schizophrenia, depressive or related disorders.

All Participants were given six pounds an hour in payment for participating in this study; they were also offered the covering of travel costs to and from the research site.
Table 2A. Demographic information for the schizophrenia outpatient participants (SOP) and healthy control participants (HCP)

<table>
<thead>
<tr>
<th></th>
<th>SOP (N=13)</th>
<th>HCP (N=13)</th>
<th>Statistical Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ±SD</td>
<td>Mean ±SD</td>
<td>df</td>
</tr>
<tr>
<td>Age (years)</td>
<td>42.46±9.00</td>
<td>39.77±8.84</td>
<td>24</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>9/4</td>
<td>9/4</td>
<td></td>
</tr>
<tr>
<td>Education Level (own/father’s)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pre-GCSE</td>
<td>2/4</td>
<td>0/4</td>
<td></td>
</tr>
<tr>
<td>GCSE</td>
<td>4/2</td>
<td>1/5</td>
<td></td>
</tr>
<tr>
<td>A-Level</td>
<td>3/4</td>
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<tr>
<td>Degree</td>
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<td>4/0</td>
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</tr>
<tr>
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<td>2/1</td>
<td></td>
</tr>
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<td>Ethnicity</td>
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<td>White British</td>
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<td>11</td>
<td></td>
</tr>
<tr>
<td>Indian British</td>
<td>4</td>
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<tr>
<td>Hispanic</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mixed Race</td>
<td>1</td>
<td>1</td>
<td></td>
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<tr>
<td>WAIS-IV Scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Design</td>
<td>8.85±2.51</td>
<td>13.23±2.28</td>
<td>24</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>7.54±3.04</td>
<td>12.31±2.81</td>
<td>24</td>
</tr>
<tr>
<td>Information</td>
<td>10.77±2.62</td>
<td>13.23±2.65</td>
<td>24</td>
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<tr>
<td>Coding</td>
<td>8.08±2.33</td>
<td>12.08±2.43</td>
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<tr>
<td>FSIQ- Estimate</td>
<td>91.54±13.79</td>
<td>119.08±10.63</td>
<td>24</td>
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<tr>
<td>BPRS</td>
<td></td>
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</tr>
<tr>
<td>Affect</td>
<td>9.23±3.27</td>
<td></td>
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</tr>
<tr>
<td>Positive</td>
<td>6.23±2.55</td>
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</tr>
<tr>
<td>Negative</td>
<td>6.00±2.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activation</td>
<td>4.15±1.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance</td>
<td>4.77±2.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30.38±6.92</td>
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<tr>
<td>Illness Duration</td>
<td>14.31±8.08</td>
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<tr>
<td>Medication Dose (Chlorpromazine Equivalent)</td>
<td>552.42±242.64</td>
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</tr>
</tbody>
</table>

2.3.1.2. Design

The attention part of this study was mixed design, where two groups of participants (the schizophrenic group and healthy controls) were compared on their performance on a cued attention task consisting of several repeated measures factors. The independent factors in this task were target contrast levels (four levels that increased in steps of 15.63% from 31.25%-78.13%); cue location (2 levels: left/right); target presence (present on 50% of trials), and for the signal-only trials there was also cue type (2 levels: valid /invalid with 70% validity). The performance measures for the cueing task were the same as for the experiment 1: d’ (target sensitivity), weighting,
criterion ($\lambda$), and response times for the all-trial analysis, and hit rate and response time for the signal trials.

### 2.3.1.3. Materials

The 18-item Brief Psychiatric Rating Scale (Overall & Gorham, 1962) was administered during an interview by a psychiatrist. The Brief Psychiatric Rating Scale (BPRS) is a standard instrument used across research in order to assess the current symptomology for individuals with psychotic disorders. It was created for research purposes and is stated to cover positive, negative and affect symptoms. The BPRS is conducted through an interview with the individual being assessed, and the interviewer, in this case a psychiatrist, rates each of the 18 items (for example, grandiosity, motor retardation, and anxiety) on a scale of 1 (not present) to 7 (extremely severe). It has been reported to have good inter- and intra-rater reliability (Dingemans, Frohndewinter, Bleeker, & Rathod, 1983). An example of the BPRS can be found in Appendix B.

Four subtests from the Wechsler Adult Intelligence Scale (4th ed. UK; WAIS-IV) were administered to all participants in order to estimate IQ (Wechsler, 2010), which represented the four main indexes. These were Block Design (perceptual organization index) where participants have to make patterns from three-dimensional block shapes, Arithmetic (working memory index) which is timed, Information (verbal comprehension index) where participants are required to answer general knowledge questions and Coding (processing speed index), where participants are required to fill boxes with symbols defined by numbers within a time limit. These subsets were chosen based on Blyler, Gold, Iannone and Buchanan’s (2010) suggestion for a shortened version of the WAIS for use in patients with schizophrenia.

The COVAT task was written and presented in the same way as for experiment 1, but for this task there were four levels of target contrast instead of the two presented before, and no double-cue trials. The target varied across contrast levels of 31.25% for the low contrast, 46.88% and 62.5% for the middle two contrast conditions and 78.13% for the high contrast condition. Examples of typical stimuli can be found in Figure 2.10.
Figure 2.10. Examples of stimuli used in experiment two presented in trial presentation order

2.3.1.4. Procedure

Participants were tested individually during this study. The study took part over either two or three sessions, based on the length of session the participants were happy to complete, each lasting between one and one and a half hours, and was conducted within the School of Psychology at the University of Leicester. The set-up and trial sequence for this experiment followed the same protocol as experiment one, but with the exclusion of the double-cue. The practice block also differed to take into account the lack of experience in psychophysical testing for this group. All participants started the first session with a practice block for the cueing task; this was created such that the non-target pedestal was absent to check that they could distinguish a target from the background. They were then given a further practice, this time with the pedestal present and set at the highest contrast level, in order that they could practice distinguishing the target from background noise. The participants (regardless of group) then completed the cueing task in 24 blocks of 40 trials. The trials within each block remained constant for contrast level, and the participants were told which level it would be prior to beginning the block; the rest of the factors varied randomly throughout the blocks.

Half way through each of the sessions, in between cueing task blocks, the participants were administered parts of the WAIS subtests and the clock drawing test.
(in that order), in an interview setting under a psychologist’s instruction. The participants in the schizophrenic group were also interviewed for BPRS assessment during one of their participation sessions. This was conducted by an NHS psychiatrist who was blind to the nature of the study, and participants’ performance, on the attention task.

2.3.1.5. Data Analysis

In order to obtain an estimation of the full scale IQ from the subsets used in this study, the averages of the four subtests used were multiplied by the total number of core subtests available to use (10 for the WAIS-IV); these scores were then converted to FSIQ scores based on the WAIS-IV (UK) scoring manual. This followed the original method used by Blyler, Gold, Iannone, and Buchanan (2000).

As well as the total score for the BPRS factor scores were also computed based on Shafer’s (2005) meta-analysis of BPRS studies involving schizophrenic participants. The names and items making up the factors were: Affect (depressive mood, anxiety, guilty feelings and somatic concern); Positive symptoms (unusual thought content, hallucinatory behaviour, grandiosity and conceptual disorganisation); Negative symptoms (blunted affect, emotional withdrawal, disorientation, and motor retardation); Activation (excitement, tension and mannerisms-posturing); Resistance (uncooperativeness, hostility and suspiciousness).

In order to examine whether drug doses had an effect on attentional performance the drug doses were transformed into Chlorpromazine equivalent doses. This was done using the tables detailed in the Gardner, Murphy, O'Donnell, Centorrino, and Baldessarini (2010) study, which represent a consensus of highly experienced healthcare professionals.

Initially the responses from the task were screened in the same way as described in experiment one leading to a proportion of .026 of trials to be excluded from analysis.

The responses in the attention task were used to create two data sets to be analysed separately for all the trials and the signal-only trials, MANOVAs were then performed as in experiment one, as well as the one-tailed t-tests for the cue weighting measure analysis. A mixed MANOVA was then conducted in order to look at the differences between the groups. Finally, MANCOVAs were conducted looking at the effects of the WAIS, BPRS, Drug dose, and illness duration on attention performance. Illness duration was measured in years from the time of initial diagnosis of
schizophrenia to time of participation in the current study. Post hoc tests were conducted using the same method as experiment one.

2.3.2. Results and Discussion

2.3.2.1. Effects of Within-Participant Factors: Overall Attention Performance

The data were analysed initially to look at trends in the whole sample, regardless of group; the main effects are displayed in Table 2.5 below. There was a significant main effect of contrast for all the measures in this study; for d’ and response time for all-trials there was a significant difference on all the levels of contrast, with d’ increasing with contrast and response time decreased with contrast. On the signal trials, the hit rate increased across the three lowest conditions, but there was no significant difference between the two highest conditions; this was consistent with response time, as the response times were significantly faster as the target contrast increased, although there was no significant difference again across the last two levels. The effect of contrast on the response time and performance measures (d’ and hit rate) is consistent with the student sample and it was expected. These results suggest that as a whole sample, participants reached a ceiling level for the two highest levels of target contrast as their performance stopped improving.

The criterion measure also only differed significantly between the lowest contrast condition and the two highest contrast conditions, moving towards a more negative criterion (indicating a bias for more ‘yes’ responses) as the contrast levels of the target increased; therefore following the pattern of the student sample. For the weights measure there was only a significant difference between the highest and lowest contrast levels, with weighting in the highest contrast condition closer to the optimal cue weighting. The effect on the weighting measure was not predicted as it would be expected to be constant across contrast levels like in the student sample, as the strategy would not need to change. If there was a difference across contrast levels, it would be expected that individuals would use the cue information more when the contrast was lower as the task would be harder and they would need to rely in this information in order perform optimally. This is the opposite to the finding, so it is a little harder to explain, perhaps as the task got easier the participants were able to use the cue information more easily.
There was also a main effect of cue side (see Table 2.5). This was only significant for response time, but was consistently significant across both all-trial and signal-only analysis. The means revealed that the sample as a whole was faster on trials with right-, rather than left-, sided cues. This appears to show that there was a right visual field advantage, which is inconsistent with the student sample, however in the student sample the asymmetry was related to target side (this analysis was done due to the neutral double cue making a cue side analysis more complicated). So it may be easier to get a picture once the cue type x cue side interaction is examined, as this will show whether there are consistencies.

To examine whether the participants were using the cue validity information one sample t-tests comparing the average cue-weighting to the optimal value of 70, and the equal weighting value of 50 were conducted. All weightings significantly differed from 70, (low contrast: \( t(26)=-5.579, p \leq .0005 \); low-medium contrast \( t(26)=-4.670, p \leq .0005 \); high-medium contrast \( t(26)=-3.168, p = .004 \); high contrast \( t(26)=-2.866, p = .008 \)); the three lowest contrast levels conditions did not significantly differ from equal weighting level but there was a significant difference for the highest level of target contrast \( (t(25)=2.152; p = .041) \). For the signal-only analysis the main effect of Cue Type was found to be non-significant \((F(2,24)=1.358; p = .276)\). This suggests that there were no direct effects of the cues, and the participants were not using the cue information provided in the instructions, thus, replicating the finding in the student sample. There is some evidence that the participants in this experiment were using the cue information a little, if not optimally, in the highest contrast condition. It may be that once the task was made easier they were able to use the cue information, however, it would be expected that they had consistent strategy across the contrast levels.
Table 2.5. *Table of main effects from multivariate analysis of variance for all-trials*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Contrast</th>
<th>df</th>
<th>F</th>
<th>η²</th>
<th>High M(SE)</th>
<th>Medium-High M(SE)</th>
<th>Medium-Low M(SE)</th>
<th>Low M(SE)</th>
<th>df</th>
<th>F</th>
<th>η²</th>
<th>Left M(SE)</th>
<th>Right M(SE)</th>
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<tbody>
<tr>
<td>Overall Response Time(ms)</td>
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<td>.293</td>
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<td></td>
</tr>
<tr>
<td>Criterion</td>
<td>2.62,65.50</td>
<td>28.60</td>
<td>.534</td>
<td>722(52)</td>
<td>736(53)</td>
<td>773(54)</td>
<td>834(55)</td>
<td>1.24</td>
<td>5.69*</td>
<td>.192</td>
<td>772(53)</td>
<td>761(53)</td>
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<tr>
<td>Weights d'</td>
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<td>3.17*</td>
<td>.112</td>
<td>58.58(3.89)</td>
<td>51.04(5.70)</td>
<td>45.02(5.36)</td>
<td>41.27(5.24)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-1.11(.21)</td>
<td>-.89(.16)</td>
<td></td>
</tr>
<tr>
<td>Overall Response Time(ms)</td>
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<td>.431</td>
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<tr>
<td>Criterion</td>
<td>3.75,54.11</td>
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<td>682(54)</td>
<td>736(59)</td>
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<td>719(55)</td>
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<td>.94(.03)</td>
<td>.87(.03)</td>
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<td>-</td>
<td>-</td>
<td>.86(.03)</td>
<td>.861(.02)</td>
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</tr>
</tbody>
</table>

¹Pillai’s Trace Reported
For all significant results *p*<.01 except *significant to p*<.05
Denotes non-significant finding
Although there were no significant interactions for the all-trial analysis, there were some significant interactions indicated for the signal-only analysis. Firstly, a significant interaction between cue type and cue side \((F(2,24)=5.813; p=.009; \eta^2=.326)\), depicted below in Figure 2.11, for the response time measure only \((F(1,25)=9.460; p=.005; \eta^2=.275)\) was shown. Post hoc t-tests revealed that participants were significantly \((t(25)=3.512; p=.002)\) faster at responding to right cued invalid trials \((M=703; SD=274)\) over left cued invalid trials \((M=764; SD=306)\), whereas there was no significant difference for valid trials \((t(25)=2.005; p=.056)\). This indicates that the main effect of cue type was mostly due to this difference across cue side for the invalid trials, where participants were faster on the right cued (and left target) trials than the left cued (right target) trials. This is consistent with the student sample that also had faster responses for the left target trials, although not specifically for invalid trials.

There was also a significant interaction between contrast and cue side \((F(6,150)=2.203; p=.046; \eta^2=.081)\), which was shown to be significant for response time only \((F(3,785)=3.69; p=.031; \eta^2=.081)\). This is depicted in Figure 2.12. Post hoc t-tests revealed that there was a significant difference in the lowest contrast condition between left and right cue trials \((t(25)=3.167; p=.004)\), with faster response times for the right-sided cue trials \((M=839; SD=288)\) than left-side cue trials \((M=793; SD=292)\). This difference was non-significant for all other contrast levels. Therefore, the difference across the cue sides for response times was only evident for the most
demanding contrast level, the graph also indicates that the participants were either at or near ceiling level for the other contrast levels, and therefore no difference was found.

2.3.2.2. Group Differences on Attention Measure

Although there was no overall group difference on the all-trial analysis, there was a significant difference for the d’ \( F(1,24)=6.725; p=.016; \eta^2=.219 \) and response time measures \( F(1,24)=4.793; p=.039; \eta^2=.166 \); these are shown in Figure 2.13. This manifested as a lower d’, and therefore poorer target sensitivity, in the schizophrenic group \( (M=2.70; SD=1.15) \) when compared with the control group \( (M=3.57; SD=.37) \). The response times were also slower for the schizophrenic group \( (M=882; SD=358) \) than the control group \( (M=650; SD=133) \). For the signal-only trials there was a main effect of group for hit rate only \( (F(1,24)=5.062; p=.034; \eta^2=.174) \), also shown in Figure 2.13, where the control group had a higher hit rate \( (M=.910; SD=.047) \) than the schizophrenic group \( (M=.812; SD=.150) \).
These findings are consistent of the predictions made for this study, as the individuals diagnosed with schizophrenia show both poorer performance, with the lower hit rate and d’ averages, and slower response times. The response time finding in particular is consistent with previous studies that have shown slower response times in this group for the standard version of the COVAT, when the target was present on all trials (Carter et al., 1992; Gold et al., 1992; Lussier & Stip, 1999; Maruff et al., 1995; Sapir et al., 2001; Strauss et al., 1992). The fact that there were no group differences on either the criterion or the cue weighting measure, suggests that the two groups did not differ in their response bias, or in their use of the cue information.

For the all-trial analysis there was a significant interaction between group, contrast and cue side \((F(12,213)=2.451; p=.005; \eta^2=.121)\); this was shown to be significant for both the d’ \((F(3,72)=3.054; p=.034; \eta^2=.113)\) and the response time measures \((F(3,72)=5.975; p=.001; \eta^2=.199)\). This interaction is shown below in Figure 2.14. Post hoc t-tests for the d’ measure indicated that the only significant difference
between groups was for the second highest contrast condition on the left-cued trials \( (t(12.372)=3.468; \ p=.004) \); the control group had a higher d’ score \( (M=4.29; \ SD=.238) \) than the schizophrenic group \( (M=2.96; \ SD=1.36) \). This appears to be showing that the control group reached the ceiling level faster than the schizophrenia group, and the schizophrenia group reached their ceiling level for right cued trials on the second highest contrast level, whereas they reached it in the highest contrast condition for left sided cues. As this finding isn’t consistent across the lower contrast levels, it may represent a slight left cue deficit, which is the opposite to what was expected in this group but not a persevering one.

For the response time measure, shown in Figure 2.15, there were no significant differences between groups, but for the control group there were significant differences between left and right-cued trials for the lowest contrast condition \( (t(12)=3.47; \ p=.005) \) Left: \( M=.741, \ SD=.157 \); Right: \( M=.710, \ SD=.154 \) and the second lowest contrast condition \( (t(12)=2.85; \ p=.015) \) Left: \( M=.659, \ SD=.146 \); Right: \( M=.635, \ SD=.134 \). This indicated that the control participants were significantly faster on right-sided cue trials than the left on the two lowest contrast conditions. There were no cue-side differences for the schizophrenia group. This seems to be suggesting that the asymmetry between the left and right present in the control group but not the schizophrenia group, which is the opposite of the prediction that the schizophrenia group would show greater asymmetries than the control group.

Figure 2.14. Mean and standard errors of d’ for the two groups across target contrast levels for left-cued trials (left) and right cued trials (right).

For the response time measure, shown in Figure 2.15, there were no significant differences between groups, but for the control group there were significant differences between left and right-cued trials for the lowest contrast condition \( (t(12)=3.47; \ p=.005) \) Left: \( M=.741, \ SD=.157 \); Right: \( M=.710, \ SD=.154 \) and the second lowest contrast condition \( (t(12)=2.85; \ p=.015) \) Left: \( M=.659, \ SD=.146 \); Right: \( M=.635, \ SD=.134 \). This indicated that the control participants were significantly faster on right-sided cue trials than the left on the two lowest contrast conditions. There were no cue-side differences for the schizophrenia group. This seems to be suggesting that the asymmetry between the left and right present in the control group but not the schizophrenia group, which is the opposite of the prediction that the schizophrenia group would show greater asymmetries than the control group.
Finally, for the signal-only trials there was a significant interaction between contrast, cue type and group \((F(6,142)=2.994; p=.009; \eta^2=.111)\), which was significant for hit rate \((F(3,72)=5.181; p=.003; \eta^2=.178)\) and response time \((F(3,72)=3.013; p=.045; \eta^2=.112)\). For the interaction on the hit rate measure, depicted in Figure 2.16, post hoc comparisons revealed that there was a difference between groups on the second lowest contrast conditions for the valid trials \((t(24)=2.846; p=.009)\), which only just failed to reach significance one pairwise adjustments to the \(p\)-value were made. For the response time measure, post hoc \(t\)-tests revealed no significant difference between the two cue types for either group, at any contrast level. There were also no significant differences between the groups on any of the contrast levels after corrections were made for multiple comparisons. There was a difference in patterns
across the contrast levels for the two groups, shown in Figure 2.17. For the schizophrenia group, on the valid trials there was significant difference between the highest and lowest contrast levels \((MD=.145, p \leq .0005)\) only; but for the invalid trials there were significant differences between the lowest contrast condition and the second lowest \((MD=.083; p = .016)\), second highest \((MD=.143, p \leq .0005)\) and highest \((MD=.125, p \leq .0005)\). There is also a significant difference between the second lowest and second highest contrast levels \((MD=.059; p = .024)\). For the control group there were significant differences between the lowest contrast condition and the second lowest \((MD=.123; p = .001)\), second highest \((MD=.166, p \leq .0005)\) and highest \((MD=.169, p \leq .0005)\) for the valid trials. This was also the case for the invalid trials (lowest contrast condition and the second lowest \((MD=.066; p = .017)\), second highest \((MD=.134, p \leq .0005)\) and highest \((MD=.118, p = .001)\)), and there was also a difference between the second lowest and second highest contrast levels \((MD=.068; p = .009)\). These interactions appear to show that all participants were significantly slower at responding for the lowest contrast condition, especially when compared to the highest contrast condition, but for the levels in between there were not always significant differences, it is clear from the graph that there was a trend for them getting faster as the contrast levels increased. The graphs also highlight the main effect of group for response time.

![Figure 2.17. Mean response times and standard errors for the two groups across contrast levels for valid trials (left) and invalid trials (right)](image-url)

2.3.2.3. Control Variables: Drug Dose and Illness Duration

The Chlorpromazine equivalent doses were examined as a covariate in MANCOVA analysis and no significant effects or interactions were found for either the
all-trial or the signal trial analysis. This implies that the differing drug doses did not impact on the response measures, however, it cannot rule out an effect of antipsychotic treatment qualitatively having an effect, in relation to the difference in group could be due to the fact that the anti-psychotic medication slowed the schizophrenia group. There was also no significant effect of illness duration on performance on the attention measures.

2.3.2.4. Brief Psychiatric Rating Scale and Attention

The BPRS total score was also examined as a covariate, and although there was no overall effect, there was a significant interaction for the response time measure between cue side and the total BPRS scores for the all-trials analysis ($F(1,11)=5.964; p=.036; \eta^2=.341$). Post hoc analysis revealed a positive correlation between cue-side difference (left – right) and total BPRS scores ($r(13)=.584; p=.036$), shown in Figure 2.18. There was also a significant interaction in the all-trial data analysis between cue side and the affect factor for response time ($F(1,11)=17.283; p=.002; \eta^2=.611$), shown in Figure 2.18. This again was a positive correlation between cue side the affect factor scores ($r(13)=.782; p=.002$). These two relationships indicate that those with higher scores on the BPRS and its affect factor were faster for right sided cues, and lower scorers showed no difference, with one individual showing a left visual field advantage. Therefore for those who scored higher on BPRS and affect factor, although they were showing a greater asymmetry which would be expected, their behaviour was actually closer to the control group’s performance, which showed the RVF advantage.

![Figure 2.18. Relationship between the Difference on the Participants’ Response Time Score for the Left and Right Cue Side Scores and the Brief Psychiatric Rating Scale Scores (left) and the Affect Factor Scores (right)](image)
For the all-trials analysis there was a significant interaction between the total BPRS score and contrast for the weights measure ($F(3,33)=4.381; p=.020; \eta^2=.285$); post hoc correlations were examined and these are reported in Table 2.6. The only significant correlation was a negative one between the BPRS scores and the second highest contrast condition, indicating that as individuals scored higher on the BPRS the weighting on the cue reduced. There was also a significant interaction between contrast and the resistance factor ($F(4,12)=4.439; p=.000 \eta^2=.357$), which was shown to be significant for the criterion measure ($F(3,33)=17.071; p=.000; \eta^2=.608$). Post hoc correlations (shown in Table 2.6) revealed a significant positive correlation between the resistance factor and the criterion score on second lowest contrast level and a negative correlation between the highest contrast level and the resistance factor. These findings show that for the weights measure individuals with higher symptom scores used the cue information less, but only for the second highest contrast condition as there were no consistent relationships for the other levels this finding is tenuous. For the resistance factor it appears that the relationship between the scores on this measure changes across contrast levels, with lower scorers more likely to respond ‘target present’ for the second lowest contrast level, and then more likely to respond ‘target absent’ for the highest contrast condition, with the reverse pattern for higher scorers. Although this inconsistency may be related to these symptoms (e.g. hostility and suspiciousness) it seems more likely it is coincidence, and it would need to be confirmed in a larger sample.

| Table 2.6. Table of correlations between brief psychiatric scores and the weights and criterion measures for each target contrast level |
|---------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                                 | Contrast Levels (Weights Measure) | Contrast Levels (Criterion Measure) |                             |
|                                 | Low | Mid-Low | Mid-High | High | Low | Mid-Low | Mid-High | High |
| Total BPRS Scores (weights)     |     |         |          |      |     |         |          |      |
| $r$                             | .267 | -.032   | -.655*   | -.084 | -   | -       | -        | -    |
| $p$                             | .378 | .917    | .015     | .785 | -   | -       | -        | -    |
| Resistance Factor Scores (Criterion) |     |         |          |      |     |         |          |      |
| $r$                             | -   | -       | -        | -    | .145| .646*   | -.382    | -.784* |
| $p$                             | -   | -       | -        | -    | .636| .017    | .197     | .002  |

There were no significant interactions for the BPRS or its factors for the signal trial analysis.
2.3.2.5. Wechsler’s Adult Intelligence Scale and Attention

Initially a one-sample t-test was conducted in order to compare the average of each group’s estimated IQ score with the average of 100. The comparison group was found to be performing significantly higher than average ($t(12)=6.637; p<.0005$), whereas the schizophrenic group was found to have an estimated IQ that was significantly lower than average ($t(12)=-2.213; p<.0005$). Schizophrenia has been widely reported to affect IQ scores, as well as being reported as a premorbid indicator of future schizophrenic disorder (Khandaker, Barnett, White, & Jones, 2011); thus the lower scores in this group were expected. The higher scores in the comparison group were probably related to selection bias, as related to a volunteer sample.

The WAIS estimated IQ and the subscale were all analysed as covariates to see if they were related to the attention measures. When the WAIS was used as a covariate, the effect of group disappeared for all measures, and the WAIS estimated IQ had a significant overall effect. The main effects of the covariates of WAIS estimated IQ and the subscales tested are shown in Table 2.7. The weights and criterion measures are not included in this table as there were no significant main effects for these measures, meaning that strategy is not related to the IQ measure used here. Overall, for the all-trial analysis, the estimated IQ and all the subscale scores were positively related to the $d’$ measure; the estimated IQ, block design and coding scores were negatively related to the response time scores. For the signal-only analysis, estimated IQ, block design and arithmetic had a significant positive relationship with hit rate. Coding had a significant negative relationship with response times. These relationships show that working memory and perceptual organization appear to be specifically linked to both the performance measures, whereas speed of processing is more related to the response time measure. The finding that IQ is related to the measures in the COVAT is understandable as attention is linked to other cognitive abilities and attention is involved in many tasks, also the individual with schizophrenia had low IQ scores the WAIS and their performance was also poorer.

When the sample was split into the two groups to be analysed, there was no effect of the WAIS on the control group, whereas there were still several main effects for the schizophrenia group on attention performance.

For the schizophrenia group, estimated IQ and arithmetic were positively related to $d’$ scores and coding was negatively related to the response time measure. The signal trial analysis indicated that the significant relationships for the schizophrenia
group were the same as shown in the group as a whole with estimated IQ, block design and arithmetic being related to hit rate and coding related to the response time performance.

There were no significant relationships between WAIS scores and dependent measures for the control group. This seems to infer that IQ was more closely related to attention performance in the schizophrenia group than the control group, implying that attention may be closely related to the variation in intellectual functioning as indicated by the WAIS scores in the schizophrenia group, and therefore more widespread deficits.
<table>
<thead>
<tr>
<th></th>
<th>Estimate IQ</th>
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<th>Arithmetic</th>
<th>Information</th>
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<td>Response Time</td>
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¹Pillai’s Trace Reported
For all significant results \( p \leq .01 \) except *significant to \( p \leq .05 \)-Denotes non-significant finding
2.4. Overall Discussion

2.4.1. Effects of Schizotypy and Schizophrenia

In experiment two in this chapter the schizophrenia group were found to be less sensitive to the target and also less able to detect it when it was present, as well as having longer response times overall, as predicted. This was consistent with previous research which indicated that those with a diagnosis of schizophrenia were slower at responding on the cueing task than comparison subjects (Carter et al., 1992; Gold et al., 1992; Lussier & Stip, 1999; Maruff et al., 1995; Sapir et al., 2001; Strauss et al., 1992). Further to this, it indicates that once individuals diagnosed with schizophrenia do attend to the target location they are poorer at interpreting the stimuli, as they tended to give fewer correct responses. Thus, this poorer attention affects their ability to interpret stimuli within the visual field.

The findings in relation to schizotypy were less clear-cut as there were no direct relationships between the schizotypy scores and any of the attention measures. However, there was an interaction between the schizotypy scores and contrast for the hit rate measure, which indicated that as schizotypy scores increased the hit rates reduced, but only on the low contrast condition. This suggests that there is an observable relationship between schizotypy and the ability to perceive a target, and that those who are higher scorers were worse at this. This is supportive of the findings with schizophrenia, but it indicates that for this more subtle relationship to be evident the task needs to be hard enough.

Unfortunately interaction between cue type, cue side and schizophrenia was not significant, this means that this study did not replicate the asymmetries found in the previous studies for individuals, where they were faster for left targets preceded by right cues than when the target was on the right and was preceded by the cue on the left (Carter et al., 1992; Posner et al., 1988; Sapir et al., 2007). This could be due to the fact the schizophrenia group were all treated with anti-psychotic medication and this may have reversed the asymmetry as suggested by Maruff et al. (1995), even though it was thought by the researchers that making the task harder with a decision task may have brought out more subtle residual deficits. It may also be related to the chronic but stable nature of the participants in this study as previously suggested by Strauss et al. (1991). There was an interaction within the schizophrenia group for the BPRS score
and also the affect factor score on this measure, and cue side for response time. This revealed that individuals who scored higher on these measures were showing a larger difference on response time between the two cue sides, with faster responses for the right cued trials. This asymmetry was actually closer to the pattern of the comparison participants, who were also faster for right-cued trials. Thus, although those with higher symptoms were displaying an asymmetry it was in line with the non-clinical samples. This may be that the higher scores were related to the affect factor scores, which are possibly representing depressive symptoms in this group, and depression is not generally related to abnormal performance on the cueing task (Cavezian et al., 2007).

There was an interaction involving cue type, contrast and schizotypy for the hit rate measure in experiment one, once this was investigated with post hoc tests, this appeared to be mainly a negative relationship between hit rate and schizotypy on the lower contrast condition for the double cue trials, although there was a slight relationship for the valid trials and the disorganized factor. As the double cue trials were the trial type that were supposed to be ‘neutral’, and there were only relationships between hit rate and schizotypy on these trials for these trials, it appears that these trials are not behaving as neutral trials with participants exhibiting markedly different performance on several measures from both the invalid and valid trials. We therefore removed the ‘neutral’ trial type from subsequent studies as they were not performing the expected role, which would be performance in between the invalid and valid trials. The reason that there was a relationship between correctly identifying a target and schizotypy on the double cue trials may be that those with lower scores could use the double cue to their advantage, in that it alerted them to attend to both locations equally, whereas the individuals with higher schizotypy scores were possibly less aroused by the double cue therefore missed some targets.

A final effect relating to schizophrenia was that there were significant relationships with the WAIS subset measures and the performance and response time measures for the schizophrenia group and not the control group. This indicates that the attention deficits found in individuals with schizophrenia, were also related to the within group variation of performance on intelligence measures, perhaps even underlying the performance on these measures. It should be interpreted with caution however, as the group sample was relatively small for correlational analysis and with a bigger sample it is also possible that there would be relationships for the control group.
as well. However, it may help to account for some of the variation of scores in the schizophrenia group, as there was a much larger variation across the performance and response time measure for this group than the control group. Thus, relatively preserved IQ scores may well indicate preserved attention functioning, however, some of the individuals in the schizophrenia group performed close to the control group on the attention measure, but their scores were still significantly lower on the IQ measure. This signals that the relationship between IQ and attention may be relative specifically to schizophrenia and represent individuals with more preserved intellectual functioning.

2.4.2. Asymmetry across participants

There was also a consistent finding across the two experiments for an overall asymmetry in the speed of responding to stimuli across the two visual fields. In experiment one, the student sample was faster at responding to targets appearing in the left visual field, and also showed a response time advantage for valid trials, where both the cue and target were presented on the left. In experiment two the sample as a whole were faster for invalid trials where the cue was presented in the right visual field, and the target was presented in the left visual field. Although these are not direct replications of one another they both indicate a bias for faster responding to the left visual field on this attention task, however, for experiment one this was not related to attention switching. This opposes some of the studies with individuals with schizophrenia, where the control groups were found to show a right visual field advantage (Gouzoulis-Mayfrank et al., 2007; Moran et al., 1992; Strauss et al., 1992; Strauss et al., 1991), however, it is consistent with a left visual field bias, representing the right hemisphere bias for attention processing (Posner & Petersen, 1990; Posner et al., 1984). This suggests that the version of the COVAT where a decision component is included is sensitive enough for individuals to exhibit this hemispheric processing bias in a behavioural manner.

2.4.3. Lack of Effect of Cue Type

Another significant finding was the lack of cueing effect for both of the samples. This goes against the findings of many previous studies both using the traditional version of the cueing task (Larrison, Ferrante, Briand, & Sereno, 2000; Maruff, Hay, Malone, & Currie, 1995; Posner, Early, Reiman, Pardo, & Dhawan, 1988; Strauss, Alphs, & Boekamp, 1992), as well as for versions where the task involves a
decision component (Eckstein, Shimozaki, & Abbey, 2002; Shimozaki, Eckstein, & Abbey, 2003; Shimozaki, Schoonveld, & Eckstein, 2012). There were no reasons to expect that it would not be demonstrated in the current sample, due to the robust nature of the cueing effect. This point will be re-evaluated in the main discussion, when it can be compared to the results from the anti-cue study.
Chapter Three

Voluntary Control of Covert Attention Shifts in Relation to Schizotypy and Schizophrenia on a Reversed Validity Cueing Task

3.1. Introduction

Reflexive orienting covert attention patterns in individuals with schizophrenia have been examined by several researchers using the Covert Orienting of Attention Task (COVAT; Posner, 1980) and generally they respond more slowly compared to control participants (Gouzoulis-Mayfrank et al., 2007). In some studies the schizophrenic group displayed an asymmetry with faster responses for left-sided targets when preceded by right cues than when these are reversed (Posner et al., 1988). The COVAT is designed to look at automatic orienting of attention; however, it has also been shown that individuals with schizophrenia show deficits with the voluntary control of attention, at least when overt attention, or eye-movements, are assessed.

The anti-saccade task (Hallett, 1978), used to measure the ability of participants to respond to a stimulus by looking in the opposite direction rather than towards it, was first used to examine attention patterns in schizophrenia by Fukushima et al. (1988). In their study individuals in the schizophrenia group could perform reflexive saccades towards the stimulus as well as the control group, but several individuals form the schizophrenia group made significantly more reflexive errors (initially looking towards the target) on the anti-saccade trials. Many studies have since replicated the finding that individuals with schizophrenia make more reflexive errors (Allen et al., 1996; Barton et al., 2002; Barton et al., 2008; Curtis et al., 2001; Franke et al., 2007; Fukushima, Fukushima, et al., 1990) and also produce longer latencies (Barton et al., 2008; Curtis et al., 2001; Reuter, Herzog, & Kathmann, 2006) when compared to healthy control groups. This poorer attention ability, and in particular higher error rates, has been attributed to problems with top-down control of attention with inhibitory processes particularly implicated, as individuals with schizophrenia’s inhibitory control is poorer at supressing the reflexive glances towards the stimulus.

Voluntary overt attention has been shown to be disrupted in the normal population within individuals scoring higher on schizotypy measures, with several
studies showing that participants who have a significantly higher level of schizotypal traits, particularly positive traits, make more reflexive errors than those with less of these traits (Aichert et al., 2012; Ettinger et al., 2005; Gooding, 1999; Holahan & O'Driscoll, 2005; Larrison et al., 2000; O'Driscoll et al., 1998). Thus, suggesting that this inhibitory deficit is associated with the schizophrenia spectrum, as well as the disorder itself. However, findings in relation to negative schizotypy traits are less consistent with Holahan and O'Driscoll (2005) finding no differences in errors when negative traits were used to differentiate between the groups, but Gooding (1999) did find a difference when using a different measure for the negative traits. This implies that the deficits in voluntary attention control, at least for eye-movements, may be more closely related to positive than negative schizotypy traits.

As there appears to be a clear deficit in the voluntary control of attention, and inhibition of reflexive orienting for individuals with a diagnosis of schizophrenia on overt attention measures, Maruff et al. (1996) postulated that this could represent a more generalised attention impairment, which would therefore also be present in tasks that involved voluntary covert attention shifts. In order to test this two studies were conducted, the first by Maruff et al. (1996) involved individuals with a diagnosis of schizophrenia and healthy control participants being presented with two blocks of trials, the first involved all valid cues and the second all invalid cues. Both of these cue types could be used to predict target location, the valid cues involved reflexive (or automatic) orienting, whereas the invalid cues involved voluntary orienting to the non-cued location. For the control group there was no difference between response times for the two blocks, indicating that they could use the invalid cues as well as valid cues. However, the schizophrenia group were significantly faster for the valid cues, implying that they were unable to inhibit the reflexive orienting to the cue location in order to benefit from the invalid cue as a predictor of target location.

The second study conducted by Maruff et al. (1998), they modified the COVAT by reversing cue validity, such that invalid cues appeared on 80% of the trials and valid cues made up the other 20% of the trials, thus becoming an ‘anti-cue’ task. In this task, like the invalid block in the previous task, participants were required to use the cue to direct their attention to the opposing visual field, as this would be the most likely target location. Maruff et al. (1998) found the control participants were able to use the cue validity information and respond faster for the invalid trials; this meant they were able to use the cue to attend to the non-cued location faster. The individuals with
schizophrenia, on the other hand, still responded faster on the valid trials, even though these were less common, thus, like previously found, they were unable to utilize the cue validity and attend to the non-cued location. This supports the idea that individuals with schizophrenia find it difficult to inhibit reflexive attention shifts even when it is advantageous to do so, and that this is evident for covert as well as overt attention.

In chapter two of this thesis, a detection version of the COVAT was administered to two samples; the first was a student sample that was also given the Schizotypal Personality Questionnaire (SPQ) to measure schizotypy, and the second was a group of individuals with a diagnosis of schizophrenia and a community comparison group. There was a general asymmetry found for response times with faster responses for the left visual field target for the students, and left targets preceded by right cues for the second sample as a whole. However, there was no relationship between the schizotypy scores and cue side, and the schizophrenia group actually showed less asymmetry than the control group. The schizophrenia group did have lower performance measure scores (hit rate and d’) as well as responding more slowly, but they did not differ on strategy measures (cue weighting and criterion). In the student sample there was a negative relationship between the total SPQ and cognitive perceptual score and hit rate measure, with higher scoring individuals having lower hit rates.

Therefore the two experiments in this chapter were designed to investigate further the relationships between covert attention and the schizophrenia spectrum, this time looking at voluntary covert attention. Experiment one is conducted with a student sample who were assessed for schizotypal traits, with experiment two consisting of the group of individuals diagnosed with schizophrenia and comparison group used in chapter two. Both of these samples completed a target presence judgement version of the modified COVAT, similar to the one reported in chapter two but with reversed cue validity, so that invalid cues are more frequent. It is expected that there will be a group difference on response times and performance as well as a relationship between schizotypy and performance, with poorer performance in relation to schizophrenia and schizotypy thus replicating the results of chapter two. It is also predicted that there will be an interaction between cue type and schizotypy in the first experiment, and cue type and group in the second experiment, with schizotypy and schizophrenia being related to persistent reflexive strategies and therefore better performance on the valid cued trials, even though the invalid trials will be more common. Those who score lower on the
schizotypy measure, as well as the comparison group, are expected to be able to switch attention strategy with better performance on the invalid trials.

3.2. Experiment One

3.2.1. Method.

3.2.1.1. Participants.

There were 81 participants who completed this study; 29 of these were male and 52 were female. The sample had a mean age of 20.09 years ($SD=3.78$). All the participants that took part in this study were undergraduate students from the University of Leicester who participated as part of their course requirement. All participants had a high level of English required for participation in their degree course; they all had normal or corrected to normal vision.

3.2.1.2. Design

As with the first study, two data sets were created; one with the data for all the trials, and another for the signal only trials. This is in order to look into the effect of cue type on performance. The independent variables for this study were cue side (either left or right), target contrast levels (2 levels of peak contrast 31.25% and 46.88%), target presence (present or absent), and for the signal trials there was also cue type (invalid or valid) with a cue validity of 30%, and target side (left/right). The dependent variables for this experiment were the same as those used in Chapter 2 consisting of $d'$, cue weighting (weights), criterion ($\lambda$) and response time for the all-trial analysis; for the signal-trial analysis the dependent variables were hit rate and response time.

3.2.1.3. Materials

Raine’s Schizotypal Personality Questionnaire (SPQ) was again used to measure schizotypy in this study; see Chapter two and Appendix C for full details of this measure. The SPQ was administered as a paper and pen test.

The stimuli, computer programme and computer set up used in this study were the same as those used for the cueing studies; see the previous chapter for a description of these.
3.2.1.4. Procedure

The set up and procedure for this study were fundamentally the same as the experiment one in Chapter two; with a typical trial also following the same sequence. The participants also completed a practice block of trials in this experiment, and like the previous Chapter this block was set at the higher contrast level. Participants then completed four blocks of 90 trials, two in each session. Two of these blocks presented the target at the higher contrast and two with the target at the lower contrast; participants were informed of the contrast level prior to each block. The other independent variables (cue type, signal presence, cue/target side) varied randomly but proportionately (as described in the design section) throughout the blocks.

3.2.1.5. Data Analysis

Initially trials where the participants responded faster than 100ms or slower than 3000ms were removed as anticipatory responses or trials where the participant missed the target; this led to the exclusion rate of .042 trials. Following this, the participants’ hit rates and false alarm rates were then used to calculate their approximate weighting, criterion and d’ values based on a chi-square fit to the Monte Carlo simulated models as described in the ideal observer analysis section in the introduction. The response times were taken by averaging all the responses over the appropriate trials, and average hit rate was also calculated for the signal trials.

The participants’ scores for the Schizotypal Personality Questionnaire were calculated in the same way as for Experiment one in Chapter 2. MANOVA’s were performed in order to analyse the possible effects of the independent variables for each of the data sets. Four MANCOVAs were then performed for each of the two data sets, with the covariates of the total SPQ score, Cognitive-perceptual, Interpersonal and Disorganized factors examined individually in each. Post hoc t-tests were performed for the within-participant interactions. For the interactions that included covariates, correlations were measured between the covariate and computed difference variables for each of the independent measure involved.
3.2.2. Results

3.2.2.1. Schizotypal Personality Questionnaire.

The means and standard deviations for the participants’ scores for the total and factors are shown in Table 3.8. Graphs of the distribution of scores are shown in Figure 3.19. The Schizotypal Personality Questionnaire means and spread were very close to those found in the first student study described in the Chapter two. The total scores on SPQ follow a normal (skewed) distribution, with perhaps two outliers at the higher scoring end. All the distributions were skewed towards lower scores; once again this is in line with the Chapter two and the idea of schizophrenia as a skewed continuous distribution (Van Os et al., 1999).
Table 3.8. Descriptive statistics for schizotypal personality questionnaire total and factor scores

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Score</td>
<td>20.32</td>
<td>12.36</td>
</tr>
<tr>
<td>Cognitive Perceptual Factor</td>
<td>8.09</td>
<td>6.34</td>
</tr>
<tr>
<td>Interpersonal Factor</td>
<td>9.23</td>
<td>6.39</td>
</tr>
<tr>
<td>Disorganized Factor</td>
<td>5.16</td>
<td>3.54</td>
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</table>

3.2.2.2. Attention Measure Within-Subjects Effects

The main effects for the attention measure for all participants are detailed in Table 3.9. The significant main effect of contrast was consistent for all measures except criterion. It was evident that performance was generally better for the higher target contrast trials, as indicated by higher hit rates and d's, as well as faster response times. This is consistent with the findings in Chapter two, and expected as a higher...
contrast target would be easier to detect. The cue weighting was also closer to optimal weighting on the lower than the higher contrast condition; this may be that as participants found the lower contrast target more difficult to detect, they relied more on the cue information to indicate the most likely target location.

The all-trial analysis indicated that participants were much faster at responding to left-cued trials which is a direct replication of Chapter two’s results, and when taken with the signal trial analysis indicates that participants were significantly faster at responding to left cued trials for the non-signal trials. This was reversed for the signal trials indicating that, as invalid trials were more common in this task, participants were able to switch their attention focus from right cues to left targets faster than when these were reversed.

The main effect of criterion indicates a change in bias over the two sides, with a greater bias towards indicating a target was not perceived for the left-cued trials. This finding is a little unclear as it suggests that participants were more biased for left cued trials, and therefore their strategy for this side was not as optimal. This could be that they were been missing targets on the right due to attention initially being directed by the cue to their dominant side.

There was also a main effect of cue type indicating better performance for the invalid trials, with higher hit rates and faster response times on these trials compared to the valid trials. This indicates that participants were able to use the cue information effectively, and switch to voluntarily attending to the non-cued location. This meant participants identified the target more quickly when it was presented in the non-cued location, instead of the cued location where the target appeared less often.

In order to look at the participants use of the cue across all trials (both signal and noise trials) one-sample t-tests were also conducted with the weights measure; these were to compare the weights to optimal weighting (30 based on cue validity) and equal weighting (50 due to there being two locations). Overall the weighting ($M=33.27; SE=2.4$) did not significantly differ from the optimal weighting ($t(80)=1.366, p=.176$), and did significantly differ from equal weighting ($t(80)=-6.98; p \leq .0005$). Once the weights were split into contrast levels, the weights score for both contrast levels differed significantly from equal weighting (high: $t(80)=-8.78; p \leq .0005$, low: $t(80)=-3.69; p \leq .0005$), but only the high contrast weighting also differed significantly from optimal weighting ($t(80)=3.629; p=.001$), whereas the low contrast average weighting did not ($t(80)=-1.26; p=.210$). The fact that the weights overall were
very close to optimal weighting indicates that participants were using the cue information in this study, unlike the in the last chapter where they did not differ from weighting the cue and non-cue location equally. It also suggests that participants used the cue more optimally in the lower contrast condition (although a little less than optimal), whereas it was sub-optimally used in the higher contrast condition; this was probably due to the cue being utilized more in the more difficult condition.
### Table 3.9: Table to show the main effects of contrast, cue side and cue type for all-trials and signal-trials analysis

<table>
<thead>
<tr>
<th>Measure</th>
<th>Contrast</th>
<th>Cue Side</th>
<th>Cue Type</th>
<th>All Trials</th>
<th>Signal Trials</th>
</tr>
</thead>
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<tr>
<td></td>
<td>df</td>
<td>F</td>
<td>$\eta^2$</td>
<td>M(SE)</td>
<td>M(SE)</td>
</tr>
<tr>
<td>Contrast</td>
<td>df</td>
<td>F</td>
<td>$\eta^2$</td>
<td>M(SE)</td>
<td>M(SE)</td>
</tr>
<tr>
<td>High</td>
<td>4.77</td>
<td>78.15</td>
<td>.802</td>
<td>4.77</td>
<td>6.21</td>
</tr>
<tr>
<td>Low</td>
<td>1.80</td>
<td>26.57</td>
<td>.549</td>
<td>1.80</td>
<td>17.8</td>
</tr>
<tr>
<td>Cue Side</td>
<td>df</td>
<td>F</td>
<td>$\eta^2$</td>
<td>M(SE)</td>
<td>M(SE)</td>
</tr>
<tr>
<td>Left</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Right</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Cue Type</td>
<td>df</td>
<td>F</td>
<td>$\eta^2$</td>
<td>M(SE)</td>
<td>M(SE)</td>
</tr>
<tr>
<td>Invalid</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Valid</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

- Denotes non-significant finding

Pillai’s Trace Reported
For all significant results $p \leq .01$ except *significant to $p \leq .05$

85
There were no significant interactions for the all-trial analysis; however, there were two interactions for the signal-trial analysis. The first was a significant interaction between cue type and cue side ($F(2,79)=20.528; p=.000; \eta^2=.342$), which was significant for both hit rate ($F(1,80)=15.433; p=.000; \eta^2=.162$), and response time ($F(1,80)=29.551; p=.000; \eta^2=.270$); these are shown in Figure 3.20 below. Post hoc t-tests revealed that, for the hit rate measure, the difference between invalid and valid hit rates was larger for right-cued trials ($MD=.17, SE=.02, t(80)=7.44; p\leq.0005$) than for left-cued trials ($MD=.05; SE=.02, t(80)=2.33; p=.022$). There were also significant differences between cue sides for both the invalid ($MD=-.06 t(80)=-3.783; p\leq.0005$) and valid measures ($MD=.07 t(80)=3.264; p=.002$). As the highest hit rates were on the right-sided invalid trials, when the participants were required to shift attention from right to left, and the worst performance was for right-sided valid trials. This indicates poorer performance for the right visual-field generally but, the cue validity seems to have a larger effect than the stimuli side as participants performed better on invalid trials where they were required to switch attention to the right from the left than valid left trials.

For the response time measure there was a significant difference between invalid and valid trials for right-cued trials ($t(80)=8.34; p\leq.0005$), with faster responses for invalid trials ($M=.56; SE=.01$) than valid trials ($M=.63; SE=.02$), but this was not significant for left-cued trials ($p=.190$). This indicates that the effect of validity found for the hit rate measure is only significant for the right-cued trials, which supports the left-visual field bias, as it effectively means that individuals were faster at directing...
their attention to the left-visual field away from a right cue, than towards the right cue. The differences between left and right-cued trials were significant for both invalid (MD=39 \( t(80)=6.132; p\leq.0005 \)) and valid (MD=-23 \( t(80)=-3.452; p=.001 \)). This again supports the left visual field advantage, with participants responding faster for trials with left targets across both the trials types (faster for right-cue invalid trials and left-cued valid trials). Therefore, stimuli side seems to be dominant, over trial type for response time, as this was consistent across trial types whereas there was only significant difference for the right-cued trials between the trials types.

There was also a significant interaction between cue type and contrast levels \((F(2,79)=29.04; p=.000; \eta^2=.424)\); this was significant for hit rate only \((F(1,80)=58.35; p=.000; \eta^2=.422)\), as shown in Figure 3.21. Post hoc t-tests indicated that there were larger differences between the high and low contrast hit rates for valid trials \((MD=.20; SE=.01, t(80)=14.72; p\leq.0005)\) than for invalid trials \((MD=.10; SE=.01, t(80)=10.59; p\leq.0005)\), with higher hit rates for the high contrast condition. There was also a larger difference between invalid and valid trial hit rates for the low contrast condition \((MD=.17; SE=.02, t(80)=8.17; p\leq.0005)\) than the high contrast conditions \((MD=.17; SE=.02, t(80)=4.17; p\leq.0005)\). Again both had higher hit rates for the invalid condition than the valid condition. This interaction shows that the participants were more affected by the cue type in the low contrast condition, where the difference was much larger. This is consistent with the weighting measure where the cue weighting was optimal for the lower contrast condition, and although it was less than equal weighting it did not reach optimal level for the higher contrast condition. This is probably due to participants getting closer to a ceiling level performance as the task got easier, such that it got to the point where the cue was utilized less as the target was salient enough to negate a cue effect.
3.2.2.3. Schizotypy Covariate Analysis

There were no main effects of the four schizotypy measures (total, cognitive-perceptual, interpersonal and disorganized scores) for either the all-trial or the signal-trial analysis. Therefore there was not a main effect of schizotypy on performance as predicted for this study. There was also no significant relationship between schizotypy and cue type for either the response time or the hit rate measures. This indicates that participants who scored higher on the schizotypal measure, and its factors, did not persist with better performance on the valid trials, so that prediction was not supported.

However, there were three significant interactions involving schizotypy scores and the independent variables in the all-trial analysis. The first significant interaction for the all-trial analysis was between contrast and the interpersonal measure; this was significant for the response time measure ($F(1,79)=3.987; p=.049; \eta^2=.048$), shown on the left in Figure 3.22 below. For the post hoc analysis the difference between response times for the two contrast levels was assessed, as described in the data analysis section, in order to relate participants’ scores for the two contrasts to each other. The correlation between this and the interpersonal factor score was calculated. There was a positive correlation between the difference in response time and the interpersonal factor scores ($r=.219; p=.49$), thus suggesting that those that scored lower on the interpersonal factor were faster for the high contrast condition; however, as individuals scored higher they either showed no difference between response time or were slightly faster for the lower contrast condition. This interaction is somewhat difficult to interpret, although it does appear to suggest that the individuals who scored higher were not benefiting from the higher contrast condition in in terms of their response times.

Figure 3.21. Means and standard errors for the interaction between contrast and cue type on the hit rate measures

3.2.2.3. Schizotypy Covariate Analysis

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This relationship does not seem particularly strong, as suggested by the Figure 3.22 and this is backed up by a borderline p-value and a low effect size.

The second interaction indicated that there was a relationship between cue side and the disorganized factor for the d’ measure ($F(1,79)=7.409; p=.008; \eta^2=.086$), shown on the right in Figure 3.22. Post hoc correlations between the disorganized factor and the calculated differences between d’ for cue sides (left-right cued trials) revealed a positive relationship between the two ($r=.293; p=.008$). Thus, those who scored lower on the disorganized factor were more sensitive to the target on the right cued trials, whereas those who scored higher tended to be more sensitive to the target on left cued trials. This indicates that in relation to schizotypy there were also asymmetries across the visual field for the d’ measure. As the sample overall was faster at responding to left-cued trials, the participants who scored lower on the schizotypy measure were demonstrating a speed accuracy trade off as their accuracy was better for the right-cued trials. However, those who scored higher on the disorganized measure showed a more consistent asymmetry, with individuals both slower and poorer on trials where the target appeared in the right-visual field. This is actually consistent with the left visual field advantage shown previously in the studies with schizophrenia group (Carter et al., 1992; Maruff et al., 1995; Posner et al., 1988). Thus, suggesting that this asymmetry may extend into the normal population in relation to the schizophrenia spectrum, but specifically in relation to disorganized traits, as well as supporting its existence in those not taking anti-psychotic medication.
There was also a further interaction involving the interpersonal factor, which was between the contrast, cue side and interpersonal factors ($F(4,76)=3.997; p=.005; \eta^2=.174$), and which was significant for d’ ($F(4,76)=3.997; p=.005; \eta^2=.174$) and the weights measure ($F(1,79)=8.585; p=.004; \eta^2=.098$). Once again difference measures were created and these were then correlated with the interpersonal scores. For the d’ measure there was only a significant positive relationship between the difference between left and right cued trials and the interpersonal scores for low contrast trials ($r=.230; p=.039$) but not for high contrast ($r=.027; p=.812$). This is shown on the top left graph in Figure 3.23. This supports the relationship between schizotypy and asymmetry described above, but for the interpersonal factor it was significant only for the condition where the target contrast was lower.

![Figure 3.23](image_url)

*Figure 3.23.* Means and Standard Errors for the Interactions between The Interpersonal Factor, the Contrast and Cue Side for the Weights Measure (top left and top right) and the D’ Measure

For the weights measure, post hoc correlations were initially performed between the interpersonal factor and the difference in cue weighting between cue sides (left-
right) for each contrast level. These analyses revealed that there was a significant negative relationship between cue side difference and the interpersonal factor for the higher contrast condition ($r = -.225; p = .044$), but this relationship was not significant for the low contrast condition ($r = .126; p = .261$); this is shown in the bottom left graph in Figure 3.23. This indicates that, in the higher contrast condition, individuals who scored lower on the interpersonal measure weighted the left cues less optimally than the right, and those who scored higher weighted the right cues less optimally. Further post-hoc correlations were performed, this time between the interpersonal factor and the difference between the two contrast levels (high-low) for each of the cue sides. There was a significant relationship between the interpersonal factor and the difference between contrast scores for right-cued trials ($r = .234; p = .035$) but not left cued trials ($r = -.212; p = .058$); this is shown in the bottom right graph in Figure 3.23. This indicates that, on right cued trials, individuals who scored lower on the interpersonal scores weighted cues on low contrast trials more, whereas individuals who scored higher weighted cues on high contrast trials more. This is also reversed for left cues, but the left cue relationship does not quite reach significance. They appear to suggest that the individuals who scored lower on the schizotypy measure were using the cue validity better for right cued than left cued trials, but only on the high contrast trials. As these finding do not have a clear interpretation, it appears that there are some differences on the strategic weighting measure in relation to schizotypy, but it is not a straightforward deficit for the higher scorers as would be predicted.
3.3. Experiment Two

3.3.1. Method

3.3.1.1. Participants

The participants in this experiment were the same 26 participants that took part in Experiment two of Chapter two. The demographics for this group are summarised below, but for more detail see the previous chapter and Appendix A.

Thirteen participants formed the schizophrenic group and 13 formed the healthy control group. All the participants in the schizophrenic group had been diagnosed according to IDC-10 classification for schizophrenia and were recruited through services in Leicestershire partnership trust. All the participants in this group were taking anti-psychotic medication; three were taking traditional antipsychotics and 10 were taking atypical antipsychotics. The exclusion criteria for this group included a history of neurological or ophthalmological disease, head injuries or ECT in the last 10 years, no past history of substance dependence and no current substance abuse, as well as learning disability. The participants were also required to speak English as their main language and to have a normal or corrected to normal vision.

The 13 control participants were recruited from the community. The extra exclusion criteria for this group consisted of any history of psychiatric illness and familial history of schizophrenia, depressive or related disorders.

3.3.1.2. Design

The design for experiment two was almost identical to that of experiment one, with the only differences that the participants were divided into two groups (those diagnosed with schizophrenia and the community comparison subjects). Also there were four levels of target contrast (contrast luminance increases in steps of 15.63% from 31.25%-78.13%), with two higher target contrast levels on top of the two presented in the student study.

3.3.1.3. Materials

The computer programme, stimuli and set up used for this experiment was almost exactly the same as for experiment one with the addition of the two extra target contrast levels detailed above. The same 18-item Brief Psychiatric Rating Scale
(Overall & Gorham, 1962), scores from the previous chapter were used to assess current symptoms within the schizophrenic group and as a covariate. An example of this can be found in Appendix B. Four subtests from the Wechsler Adult Intelligence Scale (4th ed. UK; WAIS-IV) were also administered to all participants in order to estimate IQ (Wechsler, 2010). These were Block Design, Arithmetic, Information and Coding. Participants completed the WAIS-IV under a psychologist’s instruction in an interview situation. There is further description for these measures in experiment two in Chapter two.

3.3.1.4. Procedure

The procedure for this study was the same as for the study experiment two in the previous chapter, as this study was a continuation of those sessions. This study took part over either two or three sessions, each lasting between one and one and a half hours (based on how long participants could continue testing for), and was conducted within the School of Psychology at the University of Leicester. The participants (regardless of group) completed the cueing task in 24 blocks of 40 trials. The trials within each block remained constant for contrast level, and the participants were told which level it would be prior to beginning the block; the rest of the factors varied randomly throughout the blocks. A typical Trial followed the same sequence as described above in experiment one.

Half way through each of the sessions the participants were administered parts of the WAIS subtests and clock drawing test (in that order) in an interview setting before returning to another session of the cueing task. The participants in the schizophrenic group were also given the BPRS by a psychiatrist during one of their participation sessions.

3.3.1.5. Data Analysis

The estimated IQ score was the same as the one used in the cueing study, as were the Brief Psychiatric Rating Scale Scores and its factors, and also the drug dose equivalence scores. Therefore see the method section in the previous chapter (Experiment two, Chapter two) for a full description and reporting of these scores.

The data was also treated in exactly the same way as the cueing study, with trials with invalid button presses, responses faster than 100ms and slower than three seconds were all excluded. This resulted in an exclusion rate of .069 of trials overall.
The analysis of this study followed the same procedure as the analysis of experiment two in Chapter two.

3.3.2. Results and Discussion

3.3.2.1. Effects of Within-Participant Factors: Overall Attention Performance
The data were initially analysed as whole in order to look at the effects of the repeated measures prior to the group comparison. The resulting main effects of this analysis are displayed in Table 3.10 below. The main effect of contrast for the d’ measure revealed significant differences between all levels except the top two levels and the middle two levels; the d’ increased as the target contrast increased. There were no significant differences in the pair-wise comparisons for the weights measure. For the criterion and the response time measures the lowest contrast condition differed from all other levels, but this was the only significant difference. This represented slower response times for the low contrast condition and a positive criterion for the low contrast condition compared to the negative criterion for all the higher contrast conditions. The d’ and response time effects of contrast indicates the effect of contrast making the task more difficult for the participants, especially for the lowest contrast condition. The effect of contrast on criterion suggests that participants were more likely to miss the target for the lowest contrast level, which seems to make sense as the target would be harder to discriminate. However, the strategy shift to respond ‘target present’ more often in the higher contrast condition is a little less clear, but may be due to this response corresponding to the dominant (index) finger for participants. It was also a consistent strategy in this group to the one they displayed in Chapter two.
<table>
<thead>
<tr>
<th>Measure</th>
<th>df</th>
<th>F</th>
<th>( \eta^2 )</th>
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<th>Medium-High M(SE)</th>
<th>Medium-Low M(SE)</th>
<th>Low M(SE)</th>
<th>df</th>
<th>F</th>
<th>( \eta^2 )</th>
<th>Left M(SE)</th>
<th>Right M(SE)</th>
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<tbody>
<tr>
<td>Overall</td>
<td>12,222</td>
<td>7.21</td>
<td>.281</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Response Time(ms)</td>
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<td>26.80</td>
<td>.517</td>
<td>653(57)</td>
<td>657(54)</td>
<td>669(53)</td>
<td>742(57)</td>
<td>1.25</td>
<td>8.90</td>
<td>.262</td>
<td>687(56)</td>
<td>673(54)</td>
</tr>
<tr>
<td>Criterion</td>
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<td>10.46</td>
<td>.295</td>
<td>-.135(.26)</td>
<td>-.92(.22)</td>
<td>-.88(.26)</td>
<td>.23(.30)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>49.11(5.58)</td>
<td>38.70(5.06)</td>
</tr>
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<td>3,75</td>
<td>3.50*</td>
<td>.123</td>
<td>51.92(3.91)</td>
<td>42.71(3.23)</td>
<td>46.40(4.52)</td>
<td>34.60(5.27)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-69(.23)</td>
<td>-.76(.20)</td>
</tr>
<tr>
<td>( d' )</td>
<td>3,75</td>
<td>79.26</td>
<td>.760</td>
<td>4.13(.17)</td>
<td>3.82(.19)</td>
<td>3.61(.18)</td>
<td>2.44(.18)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.47(.18)</td>
<td>3.53(.15)</td>
</tr>
<tr>
<td>Overall</td>
<td>6,150</td>
<td>17.10</td>
<td>.406</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Response Time(ms)</td>
<td>3,75</td>
<td>33.46</td>
<td>.572</td>
<td>614(55)</td>
<td>626(55)</td>
<td>643(52)</td>
<td>739(57)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>655(54)</td>
<td>656(54)</td>
</tr>
<tr>
<td>Hit Rate</td>
<td>3,75</td>
<td>87.35</td>
<td>.777</td>
<td>.97(.02)</td>
<td>.95(.02)</td>
<td>.91(.02)</td>
<td>.73(.02)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>888(.02)</td>
<td>885(.02)</td>
</tr>
</tbody>
</table>

Pillai’s Trace Reported
For all significant results \( p \leq .01 \) except *significant to \( p \leq .05 \)
- Denotes non-significant finding
For the main effect of cue side, which was only significant in the all-trial analysis, the sample’s responses were significantly faster for right-sided cues than left sided cues. This is the opposite of the finding in the student sample, but it is consistent with the current samples’ performance on the cueing study in Chapter two. For the signal trials there was a main effect of cue type, shown in Table 3.11 below, which was significant for both hit rate and response time. This indicated faster response times and higher hit rates on the invalid trials, showing that this sample as a whole was using the cue validity information to focus attention on the non-cued location. This finding replicates the finding for the student sample that also performed better for the invalid trials, across both response time and performance measures.

Table 3.11. Main effect of cue type for the signal trial analysis

<table>
<thead>
<tr>
<th>Measure</th>
<th>df</th>
<th>F</th>
<th>η²</th>
<th>Invalid M(SE)</th>
<th>Valid M(SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>2.24</td>
<td>4.18</td>
<td>.258</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response Time</td>
<td>1.25</td>
<td>7.96</td>
<td>.241</td>
<td>640(53)</td>
<td>671(56)</td>
</tr>
<tr>
<td>Hit Rate</td>
<td>1.25</td>
<td>7.30</td>
<td>.226</td>
<td>.91(.02)</td>
<td>.86(.02)</td>
</tr>
</tbody>
</table>

Cue weighting was also examined with one-tailed t-tests comparing the actual weights to the optimal weighting value of 30 and the equal weighting value of 50. Overall the average weighting ($M=43.91; SE=2.67$) differed significantly from 30 ($t(25)=5.21; p<.0005$) and also significantly differed from 50 ($t(25)=-2.28; p=.031$). When the different contrast levels were assessed the lowest ($t(25)=-2.92; p=.007$) and second highest contrasts ($t(25)=-2.26; p=.033$) differed significantly from 50 and the second lowest($t(25)=3.63; p=.001$), second highest ($t(25)=3.94; p=.001$) and highest levels ($t(25)=5.61; p<.0005$) significantly differed from 30 (means and standard errors for the contrast levels are shown in Table 3.10). This indicates that participants were using the cue optimally for the lowest contrast level only, which mirrors the student sample that also only used the cue optimally in the lowest contrast level. However, the student group did use the cue optimally overall, and they used the cue, albeit sub-optimally, in the higher contrast level, whereas this group did not differ from equal weighting on two of the four contrast levels. Even though this group did not use the cue as effectively as the student sample, they did use the cue in this study, whereas they did not use it in the last chapter. This could either be that in the voluntary attention task, the difficulty made them rely on the cue more, or, perhaps the more likely
interpretation is that the participants had learned to use the cue, as they had completed this study following on from the cueing study.

There were also two interactions for the whole sample on the attention task, but only for the signal trials analysis. The first was an interaction between cue type and cue side \((F(2,24)=4.82; p=.017; \eta^2=.287)\), which was shown to be significant for the response time measure \((F(1,25)=9.12; p=.006; \eta^2=.267)\), and this interaction is depicted in Figure 3.24 below on the left. Post hoc t-tests revealed that there was a significant difference between left and right cue trials for the invalid trials \((t(25)=3.62; p=.001)\) with faster response times for right \((M=615; SE=49)\) over left \((M=665; SE=65)\) cued trials. There was also a borderline significant difference between cue sides for the valid trials \((t(25)=-2.34; p=.027)\) with faster responses for left \((M=645; SE=54)\) over right \((M=697; SE=59)\) cued trials. There was also a significant difference between cue types for the right cued trials only \((t(25)=4.87; p \leq .0005)\) where the response times were faster for the invalid \((M=615; SE=49)\) than valid trials \((M=697; SD=59)\). This finding again supports the left-visual field dominance on this task, as individuals were fastest responding to the more common invalid trials, particularly when a left target followed a right cue, and they were relatively slower for right cued valid trials, the same response time pattern shown in the student sample in experiment one.

The other significant interaction was between contrast and cue type \((F(6,150)=3.05; p=.008; \eta^2=.109)\) which was significant for the hit rate measure \((F(3,75)=5.17; p=.018; \eta^2=.171)\). Post hoc t-tests revealed a significant difference

![Figure 3.24. Graphs to show the interactions between cue type and cue side on the response time measure (left) and between cue type and contrast for the hit rate measure (right).](image-url)
between invalid and valid cues for the lowest contrast condition only ($t(25)=2.72; p=.012$), with a higher hit rate for invalid trials ($M=.785; SE=.030$) than for valid trials ($M=.671; SE=.034$). This interaction indicates that the cue type difference for the hit rate measure was evident on the lowest contrast level only. This can be attributed to a ceiling effect reached for the higher contrast conditions. This is in line with the weighting measure, where the cue was only optimally used for the lowest contrast condition, as well as the student sample that showed a larger effect of cue in the low contrast condition.

### 3.3.2.2. Group Differences on Attention Measure

There was an overall main effect of group for the all-trial analysis ($F(4,21)=3.37; p=.028; \eta^2=.391$) which was significant for both the response time ($F(1,24)=6.07; p=.021; \eta^2=.202$) and $d'$ ($F(1,24)=4.42; p=.046; \eta^2=.156$) measures. These main effects, shown in Figure 3.25, indicated that participants in the comparison group were faster at responding ($M=557; SE=29$) than the schizophrenia group ($M=803; SE=95$), and they also scored higher on the $d'$ measure ($M=3.82; SE=.13$) than the schizophrenia group ($M=3.18; SE=.28$). For the signal trial analysis there was also a significant difference between the groups on the response time measure ($F(1,24)=5.03; p=.038; \eta^2=.167$), which, like the all-trial analysis, indicated that the comparison group were faster at responding ($M=546; SE=24$), than the schizophrenia group ($M=765; SE=97$). This is also shown in Figure 3.25. This is in line with the predictions of poorer performance for the individuals in the schizophrenia group. It is also consistent with the findings in the previous chapter, where the individuals in the schizophrenia group had lower $d'$ and slower response times for the all-trial analysis. However, in the signal trials analysis in the previous study the participants differed on the hit rate measure, but not on the response time measures; this is reversed for the current experiment. This indicates that individuals with a diagnosis of schizophrenia were better at correctly identifying a present target with practice, but this compromised their response times which were now significantly slower than for the control group.
On the signal trial analysis there was also a significant interaction between the groups and cue type, which was significant for hit rate \(F(1,24)=4.56; p=.043; \eta^2=.160\). This interaction is depicted in Figure 3.26 and post hoc t-tests revealed a significant difference between cue types for the schizophrenia group only \((t(12)=3.18; p=.024)\), with a higher hit rate for the invalid cues \((M=.895; SE=.027)\) over valid cues \((M=.818; SE=.035)\). There was also a significant difference between groups on the valid trials only \((t(24)=2.52; p=.024)\) with a higher hit rate for the control group \((M=.910; SE=.011)\) than the schizophrenia group \((M=.818; SE=.035)\). As this interaction was not significant for the response time measure it can be compared to the faster response times for invalid cues in this sample as a whole, thus supporting the switch to a

\[\text{Figure 3.25. Graphs illustrating the main effect of groups on the response time (top left) and } \text{d'} \text{ (top right) measures for the all-trial analysis and the response time measure (bottom left) for the signal-trial analysis.}\]
voluntary attention strategy for the schizophrenia group. This specifically indicates that this attention switch also affected the performance in this group, with better target identification when it was presented in the more likely non-cue location, as opposed to the cue location. The performance in the comparison group, once again appears to be at ceiling level, mitigating this cue type effect for their group. Therefore in this study individuals with a diagnosis of schizophrenia were able to use the cue information and did not persist with reflexive orienting, but voluntarily moved their attention away from the cue instead.

There was also a significant interaction on the all trial analysis between contrast, cue side and group for the response time measure ($F(3,72)=3.38; p=.023; \eta^2=.123$). This interaction is displayed in Figure 3.27. Post hoc t-tests revealed that there was a significant difference ($t(12)=3.17; p=.008$) for the comparison group only between left and right cue on the second highest contrast condition, with responses to right-cued trials ($M=515; SE=27$) being significantly faster than those to left-cued trials ($M=543; SE=31$). This difference is consistent with the faster response times for right-sided cues for the all-trial analysis, as well as for the student sample on the signal trials; therefore, the fact that the comparison group, who are also from the normal population, show this is somewhat consistent. However, it would be expected to be a more consistent finding and not just present for one contrast level, especially when this level is not the lowest contrast level.
3.3.2.3. Control Variables: Drug Dose and Illness Duration

The Chlorpromazine equivalent doses were examined as a covariate in MANCOVA analysis and no significant effects or interactions were found for either the all-trial or the signal trial analysis. There was also no significant effect of illness duration on performance on the attention measures.

3.3.2.4. Brief Psychiatric Rating Scale and Attention

When the BPRS was analysed as a covariate, as well as the factors used from the study conducted by Shafer (2005), there were main effects of the Affect ($F(1,11)=5.67; p=.036; \eta^2=.340$) and Resistance ($F(1,11)=5.05; p=.046; \eta^2=.315$) factor scores on the criterion measure. The relationship of the affect factor scores and the criterion measure, shown in Figure 3.28, was a positive correlation ($r(13)=.583; p=.036$), such that the participants with higher scores were less biased, as their scores tended to 0, and the lower scorers were more biased with negative scores. On the other hand the resistance factor had a negative relationship with the criterion measure ($r(13)=-.561; p=.046$), shown in Figure 3.28; this indicated that individuals with higher resistance factor scores were more negatively biased than those with lower scores.

However, once the graph for the resistance factor and criterion interaction is examined, it appears that this relationship is mainly due to one high scoring outlier with a highly biased score. The affect factor’s relationship with criterion seems more consistent, suggesting that individuals who score higher on this measure were actually less biased,
implying that higher affect scores were related to better strategies in terms of their response bias.

There was also a significant interaction between the total BPRS score and cue side for the weights measure \((F(1,11)=6.16; p=.031; \eta^2=.359);\) this is displayed in Figure 3.29. The difference between cue side (left-right cue weight scores) had a negative correlation with the BPRS \((r(13)=-.599; p=.031),\) indicating that those who scored higher weighted the right cue more, and those who scored lower rated the left cue more. This also relates measures of strategy to the symptoms presented in the schizophrenia group, and it also reflects the relationships between the interpersonal factor scores and the cue weighting on the higher contrast level. If the graph is examined for this it actually shows that individuals in the schizophrenia group tended to weight one side much more heavily than the other, with only a few close to equal weighting. The fact that this is related to symptoms could suggest an effect of degree of residual illness affecting the strategies of this group; however, as neither the high scorers nor low scorers display an advantageous strategy, it simply highlights the range of strategies employed by this group.
Wechsler's Adult Intelligence Scale and Attention

When the estimated IQ was used as a covariate, as in the previous chapter, the effect of group disappeared for both the all-trial and the signal-only trial analysis. The main effects of the estimated IQ and the sub set scores on the attention measure are displayed in Table 3.12. For the all-trial analysis, when looking at the sample as a whole the estimated IQ, block design, arithmetic and coding scales all had positive relationship with d' scores; therefore higher scorers on these subsets and on estimated IQ had higher target sensitivity. Estimated IQ, block design, arithmetic and coding also all had negative relationships with the response time measure, indicating that the higher scorers in these subsets and estimated IQ had faster response times. Finally, coding also had a positive relationship with the criterion measure, such that the lower scorers were more negatively biased than those who scored higher on the coding measure. When groups were assessed individually there were only negative relationships between the estimated IQ and coding and response time for the schizophrenic group. Thus, for this group, those who had higher estimated IQs and coding subtest scores were faster at responding.

For the signal-only trial analysis estimated IQ, block design, arithmetic and information were all positively related to the hit rate measure, such that higher scorers in these measures were better able to correctly identify the target when it was present. Estimated IQ, block design, arithmetic, information and coding were all negatively related to the response time measure, and as before, this indicates that individuals who scored higher on these subsets responded faster to target presentations. When the groups were examined separately arithmetic was positively related to hit rate scores.
and estimated IQ and coding were negatively related to the response time measure for the schizophrenia group. For the comparison group only block design was significantly positively related to hit rate.

Overall these findings are fairly similar to those shown by the same groups on the cueing study in the previous chapter. There are however a few subtle differences, and overall there are a few less significant correlations for the schizophrenia group, as there were no longer significant relationships with the WAIS subset scores and the d’ measure for this group, as well as less significant relationships with the hit rate measure. For estimated IQ the relationships with performance measures were replaced with relationships with response times, suggesting that as performance improved for the lower scorers their response times were compromised. This is also consistent with the group difference finding, as it appears that with practice the schizophrenia group could improve their performance, but their response times were adversely affected. There were also some relationships that disappeared altogether (block design for the signal trial and arithmetic for the all trial analysis). Thus, perhaps the practice improved the attention ability in lower scorers on these measures, and it may be that the higher scorers were already near ceiling level.
## Table 3.12. Table of Main Effects of WAIS Estimate IQ and Subscale Scores

<table>
<thead>
<tr>
<th></th>
<th>Estimate IQ</th>
<th>Block Design</th>
<th>Arithmetic</th>
<th>Information</th>
<th>Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df  F  η²  r</td>
<td>df  F  η²  r</td>
<td>df  F  η²  r</td>
<td>df  F  η²  r</td>
<td>df  F  η²  r</td>
</tr>
<tr>
<td><strong>All Trials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>4.21 6.51 .551</td>
<td>1.24 8.78 .268</td>
<td>1.24 5.27* .180</td>
<td>1.24 7.35* .235</td>
<td>1.24 4.84* .168</td>
</tr>
<tr>
<td></td>
<td>4.21 3.16* .376</td>
<td>.424 7.58* .357</td>
<td>.424 7.58* .357</td>
<td>.424 7.58* .357</td>
<td>.424 7.58* .357</td>
</tr>
<tr>
<td>D’</td>
<td>1.24 12.81 .348</td>
<td>1.24 7.01* .226</td>
<td>1.24 5.83 .196</td>
<td></td>
<td>1.24 6.19 .394</td>
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<tr>
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<td>.590 .475</td>
<td></td>
<td></td>
<td>.628</td>
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<tr>
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<td>Schizophrenia</td>
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<td></td>
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<tr>
<td>Overall</td>
<td></td>
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<tr>
<td>D’</td>
<td></td>
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<td></td>
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<tr>
<td>Time</td>
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<tr>
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</tr>
<tr>
<td>Overall</td>
<td></td>
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<td></td>
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</tr>
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<td>D’</td>
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<td>Time</td>
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<td><strong>Signal Trials</strong></td>
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</tr>
<tr>
<td>Total Sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>2.23 12.23 .515</td>
<td>2.23 7.81 .404</td>
<td>2.23 8.02</td>
<td>2.23 3.87* .252</td>
<td>2.23 6.04 .344</td>
</tr>
<tr>
<td>Hit Rate</td>
<td>1.24 12.08 .335</td>
<td>1.24 11.41 .579</td>
<td>1.24 10.90</td>
<td>1.24 5.26* .180</td>
<td>.124 5.26* .180</td>
</tr>
<tr>
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<td></td>
<td>.487 .395</td>
<td></td>
<td>.575</td>
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<td>Schizophrenia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>1.11 6.02* .546</td>
<td></td>
<td>2.10 6.71*</td>
<td></td>
<td>2.10 4.26* .460</td>
</tr>
<tr>
<td>Hit Rate</td>
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<td>.573</td>
<td></td>
<td></td>
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<tr>
<td>Response</td>
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<td>.399 .632</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>.611</td>
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<td>.678</td>
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<tr>
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<td></td>
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</tr>
<tr>
<td>Overall</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hit Rate</td>
<td></td>
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<td>1.11 6.06*</td>
<td>.555 .596</td>
<td></td>
</tr>
<tr>
<td>Response</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

For all significant results \(p \leq 0.01\) except *significant to \(p \leq 0.05\). Denotes non-significant finding.
3.4. Discussion

3.4.1. Voluntary Attention Strategy Shifts

Overall the participants in both the experiments were able to shift to a voluntary attention strategy, as demonstrated by the faster response times for the invalid over valid trials. There was also a lower weighting on the cues in this study, which indicates more attentional resources being placed on the non-cue location, which is the more likely location for the target to appear in. In the previous chapter the same individuals (as those in experiment two) failed to use the cue optimally, so it seems that they had learned to use the cue in the current study.

The benefit of the invalid cues also extended to the hit rate measure, showing that participants were also correctly perceiving more targets at the non-cued location. This was evident for both the student sample and the schizophrenia group in the second experiment, therefore indicating that individuals that formed the schizophrenia group were as able as the student group to switch attention to the non-cued location. They were also more affected by the cues than the comparison group, who showed no effect of cue type on the hit rate measure, but this appears to be due to a ceiling effect for their hit rates overall.

In this study, individuals scoring higher for schizotypy traits, along with individuals diagnosed with schizophrenia, did manage to inhibit automatic covert attention shifts, in line with the task information supplied to them. Therefore the prediction of persistence in reflexive attention in relation to schizophrenia was not supported, and the findings of Maruff et al. (1998) were not replicated either, suggesting that the enduring inability to voluntarily control attention is not a consistent deficit across all groups of individuals diagnosed with schizophrenia.

3.4.2. Effects of Schizotypy and Schizophrenia

Individuals in the schizophrenia group were found to be less sensitive to the target (d’), as well as slower in responding for the all trial analysis, which is consistent with the findings for the same group in the previous chapter. However, unlike the previous chapter, individuals in the schizophrenia group correctly identified target present trials as well as the comparison participants, perhaps indicating that task practice improved their performance. This is also supported by the increased p-value
and reduced effect size for the group effect on the d’ measure in this experiment when these are compared to the same measure in the cueing study. This improvement in performance did come with a cost in the form of slowed response times on signal trials. This indicates that individuals in this group are able to modify and improve their performance with practice but only when they take more time to respond. These main effects were not replicated in relation to schizotypy, suggesting the more basic deficits are related to schizophrenia specifically and not related traits in the normal population. Another possible explanation is that the drugs that the individuals diagnosed with schizophrenia are taking are actually affecting the performance in that group. However, the dose of the drugs was not related to response time or performance, and in general anti-psychotic drugs have been shown to improve performance in individuals diagnosed with schizophrenia (Burke & Reveley, 2002), furthermore, there have not been consistent deficit findings in healthy individuals either (Barrett et al., 2004).

3.4.3. Attention Asymmetries

In the current study there were also consistent visual field asymmetries across the two experiments for the signal trial analysis. Participants in both studies show a significant interaction between left and right cue trials for invalid trials, with faster responses for right-cued trials than left cued trials. This finding suggests a left visual field advantage, because the participants were quicker to identify a target in the left visual field following a right sided cue, compared with response times for a left-sided cue and a right sided target. The asymmetry is also supported by a reversed difference across visual field (albeit borderline in the second experiment), with faster responses for trials where both the targets and cues appeared in the left visual field. However, this was not consistent for the all trial analysis across the two experiments. The individuals in the first experiment were faster for left-cue trials, whereas the participants in the second study were faster for right cues. It appears that in the schizophrenia experiment in the current study participants had an advantage to the right cues in general (as is consistent with the same individuals in the last chapter), which corresponds to expecting the target to appear in the left visual field in the anti-cueing study, whereas the student sample displayed a more straightforward advantage for left-sided cues in general.

In the student sample there was a significant interaction on the d’ measure between the disorganized factor score and the cue side variable. This indicated that
participants scoring lower on this measure were better at discriminating the target on right-cued trials, but as the scores increased this trend was reversed with the highest scorers discriminating the target more accurately for left-cued trials. The lower scorers therefore seem to be exhibiting a speed accuracy trade-off, but as scores increased there were more consistent left visual field biases. This was echoed for the interpersonal factor scores, but for the low contrast condition only. This indicates that there were more consistent asymmetries for the high scorers on the disorganized and interpersonal factors, as they had higher d’ and faster responses for the left-cued trials. This supports the previous findings of asymmetry in individuals with schizophrenia, as it follows the same pattern (Carter et al., 1992; Maruff et al., 1995; Posner et al., 1988; Sapir et al., 2001) However, as there was not a consistent relationship shown for the signal trials, it is not a direct replication of these studies, as it does not highlight the difficulty in switching attention between the visual fields, but more of a general asymmetry. Also this enhanced asymmetry demonstrated for individuals who scored higher on the schizotypy measure was not supported by the schizophrenia group, who showed no more asymmetry than shown by their comparison group. There were also some relationships with the strategic measures, cue side and the interpersonal factor in experiment one, as well as the affect factor and BPRS scores for experiment two. Thus, suggesting some effect of symptoms and traits on strategies, with individuals with higher symptom scores, and those in the student sample (but only for the higher contrast level) with higher interpersonal scores weighted right cues more than left cues. This indicates that higher number of interpersonal traits and higher symptom scores were related to more weighting the left cue more optimally.

Overall there was a general asymmetry in performance across visual field for normal participants, probably representing a right-hemisphere advantage for attention processing. Furthermore, there is a relationship between this advantage and scores on schizotypal measures, specifically in relation to the negative and disorganized traits. The fact that this is not supported by the same difference in the schizophrenia group may add some support to the idea that anti-psychotic medication has a role in the correction of this deficit for individuals with schizophrenia (Maruff et al., 1995).

3.4.4. Wechsler’s Adult Intelligence Scale Scores, Schizophrenia and Attention
Once again there were significant relationships between the performance measures and the estimated IQ and WAIS subtest scores, with some also being significant for the schizophrenia group, but only one significant relationship for the control group. This, like experiment two in the previous chapter, suggests that performance is more closely related to IQ scores in the schizophrenia group than the control group. However, as some of the relationships disappeared for the schizophrenia group, and for some a response time relationship replaced accuracy, it suggests that a practice effect also occurred within the schizophrenia group. Firstly, the lower IQ scorers appeared to improve on the performance measure, but at a cost of slowed reaction times, in some cases; and secondly, the reduced difference in performance found across the two covert studies for the schizophrenia group as a whole, when compared to the controls. This suggests that ability to attend to and respond to information in the visual field can be improved with practice in this group especially in those with the largest deficits, but at the cost of slowed responses. It may be possible that if the participants had completed more trials the response time difference would have also disappeared. This suggests that this is not an enduring deficit, and with practice it can be reduced. It would be interesting to look at whether the improved attention performance can improve the IQ test scores, indicating whether attention and IQ scores are fundamentally linked, or whether they represent separate deficits.
Chapter Four

Anti-saccade Performance on an Intermixed Pro and Anti-Saccade Task in Relation to Schizotypy and Schizophrenia

4.1. Introduction

The anti-saccade task is a well-established paradigm that has been utilized as a tool to look into the ability to voluntarily control overt attention (attention shifts measured through eye-movements), while suppressing reflexive orienting to rapid onset stimuli. Initially devised by Hallett (1978), the anti-saccade task involves the participants fixating at a central point and then being required to look in the opposing direction to a stimulus appearing either to the left or right on a horizontal axis to the central fixation point. Normal, non-clinical samples tend to produce more response errors on anti-saccade trials (by looking towards the target rather than away), and take longer to respond, compared to when they are required to look at the target in pro-saccade trials (Barton et al., 2002; Franke et al., 2007; O’Driscoll et al., 1998). Another common finding is that participants respond faster on the trials where they make a saccade error compared to when a correct saccade response is made (Brownstein et al., 2003; Schaeffer et al., 2013; Weber et al., 1998). Some studies have also found shorter amplitudes for error response when compared to correct responses (Massen, 2004; Mokler & Fischer, 1999), although amplitude is not as commonly used as a measure.

Anti-saccade abnormalities have also been well documented in individuals with a diagnosis of schizophrenia, with this group demonstrating elevated error rates (Brenner et al., 2001; Brownstein et al., 2003; Franke et al., 2007; Maruff et al., 1998), and longer latencies for the anti-saccade trials (Franke et al., 2007; Maruff et al., 1998) as well as shorter saccade amplitudes (Crawford et al., 1995; S. B. Hutton et al., 1998). This relative difficulty has been suggested to represent problems with inhibition of the reflexive glances towards the stimuli in this group, and in some patients it has been linked to abnormalities in pre-frontal cortex function (Fukushima et al., 1988; Fukushima, Morita, et al., 1990). Some studies have supported this lack of inhibitory control, as individuals with schizophrenia have been shown to make reflexive saccades towards stimuli in both when no eye-movement, or a delayed eye-movement is required.
(Brenner et al., 2001; Fukushima, Fukushima, et al., 1990). Suggesting that this is a general inhibition deficit and not just present when these individuals are primed to make an eye-movement.

There have also been several studies conducted looking into anti-saccade performance across groups who are seen as more vulnerable to schizophrenia. Studies of relatives of individuals with a diagnosis of schizophrenia have had a mix of findings, with some showing higher numbers of errors (Clementz et al., 1994; Katsanis et al., 1997) and longer latencies (Thaker et al., 1996) and others showing no heightened errors in this group (Brownstein et al., 2003; Crawford et al., 1998; McDowell & Clementz, 1997). As a result of this, one group of researchers to suggest that tasks with increased demands, particularly in relation to inhibitory load, may be required to highlight the subtle deficits in the non-clinical samples (Curtis et al., 2001).

Researchers have compared individuals from the normal population who score highly on the Perceptual Aberration Scale, which measures positive schizotypy traits, with those who score within the normal range, and shown that higher scorers have higher error rates on anti-saccade trials than lower scorers (O'Driscoll et al., 1998; Nikolaos Smyrnis et al., 2003). However, there are less consistent findings with relation to scales that measure negative traits (Gooding & Basso, 2008; Holahan & O'Driscoll, 2005), and also no difference between groups for saccade latencies has been found in these studies. The studies listed here have also all used groups that have markedly different scores on the schizotypy measures, and linear relationships between schizotypy scores and anti-saccade performance have not been examined; thus it would be supportive of the idea of a continuum if these relationships were established.

Some researchers have also varied the anti-saccade paradigm in an attempt to highlight possible underlying mechanisms for anti-saccade errors, and to determine what makes errors more or less likely. Koval et al. (2004) conducted one such study where they examined whether making the directions of an anti-saccade unequal (80 vs. 20%) affected performance. They found that there was a relative difference between the less and more likely direction (with more errors for the less likely side), but when compared to an equally likely baseline condition. Massen (2004) conducted a similar study but this time pro- and anti-saccade trials were intermixed, and the frequency was of each type was varied across three levels (25%, 50% and 75% occurrence). She found that errors on the anti-saccade trials decreased as frequency of this trial type increased. Both of these studies indicate that changing the likeliness of the trial type, or
direction, changed the performance measures with better performance in relation to the more frequent trial type. The current study was set up to see whether increasing both the difficulty based on inhibitory and working memory demands would have a greater effect on the anti-saccade performance in relation to schizophrenia and schizotypy. It also investigated whether different samples would have the ability to change strategies in order to accommodate the more likely required response.

In this chapter two different populations, students assessed for schizotypy and individuals diagnosed with schizophrenia, completed three tasks, a classic block versions of the pro- and anti-saccade tasks, a covert colour discrimination task, and a decision version of the pro- and anti-saccade tasks. In the classic anti-saccade task participants were first required to complete a block of pro-saccades, followed by a block of anti-saccades. This task was administered in order to check for the participants’ ability to perform pro-saccades, and also to look at their performance on a basic anti-saccade task. It is expected that all participants will make anti-saccade errors, but that there will be more errors in relation to higher schizotypy scores and in those diagnosed with schizophrenia. It is also possible that individuals with a diagnosis of schizophrenia will show longer latencies for the anti-saccade trials, but the relationship between latencies and schizotypy is less likely based on previous research.

The second task, called the colour discrimination task, required the participants to signal the colour of circles appearing in the periphery, in the same location as they appear in the anti-saccade tasks, while maintaining fixation on a central cross. This was conducted in order to check to see that participants were able to determine the colour of the peripheral stimuli without moving their eyes towards it. It was expected that there would be a positive relationship between schizotypy scores and the number of trials where an eye-movement was made, as well as the individuals in the schizophrenia group making more eye-movements; thus implying a more fundamental deficit of inhibiting eye-movements in general.

The third task, which constitutes the main anti-saccade task, was an intermixed pro and anti-saccade task, where blocks were presented with dominance (70%) of either pro-saccade or anti-saccade trials and the remaining proportion of the opposing trial type. The response type required was determined by the colour of circle appearing in the periphery, with the trial types randomly intermixed but following the dominance probability. In order to be successful in this task participants would have to first inhibit a reflexive response, then identify the colour of the circle without looking at it, and
finally, using information held in their working memory, use voluntary control to make the correct response based on this identification. This task therefore increased both inhibitory requirements and working memory load and it was also designed in order to see whether participants were able to adjust their strategies in order to accommodate the more likely trial type for each block type. It is predicted that participants will make more errors on both the anti- and pro-saccade trials in this task due to the unpredictability of the intermittent trials. It is also predicted that there will be an effect of task type (based on which trial type is dominant) on the error rates for each trial type, with the error rates being relatively lower for each trial type when they are dominant in the task. It is also expected that there will be higher error rates on this task with respect to schizophrenia and schizotypy, as well as individuals diagnosed with schizophrenia exhibiting more difficulty in switching strategy to accommodate the more likely trial type.

4.2. Experiment One

4.2.1. Method

4.2.1.1. Participants

There were 40 participants who completed this study; four were male and 36 female. The participants had an average age of 21.25 (SD=6.07). All the participants were undergraduate students from the University of Leicester who participated in order to earn credits as a course requirement. All the participants had a high level of English required for the participation in their degree course and normal or corrected to normal vision.

4.2.1.2. Design

The independent variables for the classic anti-saccade task were trial type (pro- or anti-saccade) and stimuli side (left or right). The measures for the classic anti-saccade task were proportion of saccade errors (where a participant made a saccade in the opposing to the required response), initial saccade latency (the time taken to make an initial saccade, measured in milliseconds), and primary saccade amplitude (measured in degrees of visual angle). Saccade amplitude and latencies were also split for the trials where a correct or error response was made.
The independent variables for the colour discrimination task were colour of the target (pink or yellow) and side that stimuli appeared on. The dependent measures were the proportion of correct responses, response times (ms) and proportion of eye-movements made.

For the main anti-saccade task the independent between participant variable was colour of stimuli and in addition to the variables used in the classic anti-saccade task there was also a task type (pro- or anti-saccade task based on which trial type was dominant in the block) variable. The measures for the main anti-saccade task were the same as for the standard anti-saccade task and comprised of saccade errors, saccade latency and saccade amplitude.

The scores on the Schizotypal Personality Questionnaire and its three factors (Cognitive-perceptual, Interpersonal and Disorganized) were used as covariates as the distributions for these measures were continuous.

4.2.1.3. Materials and Apparatus

For this study a Desktop mounted Eyelink 1000 eye-tracker was used. It had a sampling rate of 1000Hz and a spatial resolution of <.02°. The average accuracy of this Eyelink is .25-.5° according to the manual. Participants sat 50cm from the computer screen with their head on a chin rest. The stimuli for the computer task were presented on a HP Trinitron p1130 21-inch CRT monitor. The eye-tracker and monitor were controlled by a PC that they interfaced with while the experiment was running.

All the tasks were programmed using SR Research Experiment Builder software (SR Research Ltd., 2010) and the data were recorded into Data Viewer files for offline analysis. For all tasks the instructions were also presented on the screen in black and all screens had a grey background ([192, 192, 192] RGB scale, CIE (1932) coordinates: x = 0.274, y = 0.294, luminance = 39.95 cd/m²). A nine point calibration was conducted at the beginning of each task and consisted of a central location, two locations 15.64° to the left and right of this location, 11.31° above and below the centre, and four points 17.22° diagonally towards each corner of the screen from this location. These were presented in a pseudo-random sequence derived by the computer. Drift correct calibrations were also performed on all the tasks except the classic anti-saccade task; this consisted of three horizontal points across the centre of the screen, including the central point and two points 15.64° to the left and right of this point. These were presented in order from left to right across the screen.
The stimuli used in the classic anti-saccade task consisted of a central fixation circle (0.9°; 24 x 24 pixels), and circles (2.2°; 24 x 24 pixels) that appeared in the periphery of the visual field at 10.2° on the horizontal plane to the left and right of the central circle. All the circles presented in this task were black.

The stimuli used in the colour discrimination task involved a fixation cross (.5x.5) which was present throughout the trial, as well as circles (2.2°; 24 x 24 pixels diameter) that appeared 10.2° to the left and right of central fixation cross. The circles were either yellow ([255, 255, 0] RGB scale, CIE (1932) coordinates: x = 0.401, y = 0.517, luminance = 68.33 cd/m²) or pink ([255, 0, 120] RGB scale, CIE (1932) coordinates: x = 0.452, y = 0.247, luminance = 17.84 cd/m²). These circles were the same as those presented in the main anti-saccade experiment, as well as the central black circle described above that was used in the classic anti-saccade task.

Schizotypy was measured by using a paper and pen version of the Schizotypal Personality Questionnaire, an example of this can be seen in Appendix C.

4.2.1.4. Procedure

Participants took part in the study individually and completed the task in one-hour long session. All participants first completed the classic version of the anti-saccade task, followed by the colour discrimination task; finally participants were given the main anti-saccade task in four blocks, with the Schizotypal Personality Questionnaire given as a paper and pen measure after two blocks.

In the classic anti-saccade task participants were initially calibrated repeatedly, using the nine-point calibration described above, until they reached a calibration validation average of <1° error. Then participants first completed the 20 trial prosaccade task, where initially they were required to focus on the central black circle, and once this disappeared to look towards the next appearing circle either to the left or right of this. This second circle remained on screen until either the correct response was made or 3000ms elapsed. Each trial was triggered by the participant’s gaze remaining in a square invisible boundary around the central fixation point 1.5° around the central point in the screen for 1000ms (and this was the same for the colour discrimination task and the main anti-saccade task). Following this, participants then performed the 20 trial classic anti-saccade task and were given the instruction to again initially focus on the central point and once it disappeared to look away from the circles that appeared in the periphery.
For the colour discrimination task participants were initially calibrated repeatedly until they reached a calibration validation of $<1^\circ$ accuracy with an average calibration of $0.43 (SD=0.16)$ and an average maximum calibration point of $0.89 (SD=0.33)$. The participants then completed a practice block of eight trials, this was then followed by 64 trials presented in two blocks of 32, both preceded by a drift correct of the horizontal midline (outlined in the Materials section). Participants were instructed to focus on the central fixation cross throughout the task and to not move their eyes from this. They were then required to respond to circles (which appeared to the left and right of the fixation cross) by pressing the keyboard buttons ‘y’ if they perceived a yellow circle and ‘p’ if they perceived a pink circle. The stimuli remained on screen either until a button press was made or for 3000ms. They were given feedback as to whether they had responded correctly or not following each trial.

In the main anti-saccade task participants were counterbalanced to be in either the yellow or pink pro-saccade group. This meant that the yellow group were consistently required to look towards the yellow circles (pro-saccade trials) and away from the pink circles (anti-saccade trials), whereas the pink group were to make prosaccades towards the pink circles and anti-saccades away from the yellow circles. The participants completed this task in four blocks of 80 trials each; two of the blocks represented the ‘anti-saccade task’ where the dominant colour was the one participants were required to look away from, appearing on 70% of trials with the other 30% presentations of the other colour. The other two blocks made up the ‘pro-saccade task’ where the colour participants were required to look towards was present on 70% of trials. The order of these two tasks was counterbalanced across participants, and this was done equally for each of the colour groups. At the beginning of and at mid-point of the block, each of the participants were calibrated until they met an average error rate of $<1^\circ$; the participants had an average calibration of $0.54 (SD=0.18)$ and an average maximum calibration of $0.78 (SD=0.24)$. The participants were given a further two horizontal drift correct calibrations 20 trials from the beginning and 20 trials from the end of each block.

Participants were initially given a practice block of 8 trials which had an equal number of each colour circles. They then began the first of the four blocks making up the main experiment. In a typical trial, participants were required to first look at a black circle presented in the centre of the screen; this gaze then triggered the disappearance of the central circle with the simultaneous onset of the stimuli consisting
of either a pink or yellow circle to either of the horizontal positions. Based on the instructions given at the beginning of the task they would either be required to look towards or away from the stimulus. After three seconds the next trial would begin and this would continue until the block was completed. The stimulus remained on screen until either a correct response was made or for 3000ms.

4.2.1.5. Data Analysis

The eye-tracking data was processed offline in Eyelink Data Viewer (SR Research Ltd., 2011). Saccades in the current study were defined as eye-movements with a horizontal displacement of greater than 2°. All saccades with a saccade latency of less than 100ms were also excluded, and as the trial ended after 3 sec, any trial where participants failed to move their eyes within this time were also excluded. Based on these criteria the proportion of trials removed for the classic anti-saccade task was .075. For the main anti-saccade experiment a proportion of .066 of the trials were removed.

For the colour discrimination task all trials where a button other than those defined as a response button was removed, as well as trials where the participant responded faster than 100ms or took more than 3 seconds to respond. This resulted in a proportion of .004 trials being removed from the data set. One participant also had a missing data set for this task; therefore, the participants for this task totalled 39.

For the classic anti-saccade and main anti-saccade task two MANOVA analyses were conducted on the average scores representing each of the independent variable levels. The first MANOVA involved looking at the proportion of errors, saccade latencies and saccade amplitude for all the trials. Then a MANOVA was conducted comparing the saccades and amplitudes on trials where correct saccades were made with those where error saccades were made. In order to examine whether the schizotypy measures were related to the attention performance MANCOVAs were conducted with the total SPQ, Cognitive-perceptual, Interpersonal and Disorganized factors as the covariate measures.

For the colour discrimination task a MANOVA was conducted looking at the effects of the independent measures on proportion correct, response time and proportion of eye-movements. This was then followed by four MANCOVAs using the schizotypy covariates as described above.

The scores for the SPQ were calculated in the same way that was used for the previous two schizotypy studies and in line with the scoring manual (see Appendix C).
4.2.2. Results and Discussion

4.2.2.1. Schizotypal Personality Questionnaire

The average scores for the Schizotypal Personality Questionnaire are shown below in Table 4.13 and the distributions are shown in Figure 4.30. The means for the SPQ in this study are slightly, although not significantly, higher than in the previous two studies in this thesis. The distribution of the scores are generally negatively skewed, like previously found, in Chapters two and three, which seems to be supportive of the idea of the negatively skewed schizophrenia spectrum (Van Os et al., 1999). However, the distributions in this study were not as close to normally distributed as they were in previous studies; this is possibly due to a smaller sample size used in the current study. The spread of the distribution (as suggested by the Standard Deviations) were also similar to those found in the two previous schizotopy studies in this thesis.
Table 4.13. Table showing the average scores for the schizotypal personality questionnaire and the three factors.

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Score</td>
<td>23.48</td>
<td>11.63</td>
</tr>
<tr>
<td>Cognitive Perceptual Factor</td>
<td>8.93</td>
<td>6.08</td>
</tr>
<tr>
<td>Interpersonal Factor</td>
<td>10.70</td>
<td>7.15</td>
</tr>
<tr>
<td>Disorganized Factor</td>
<td>6.58</td>
<td>6.07</td>
</tr>
</tbody>
</table>

4.2.2.2. The Colour Discrimination Task

Initially the effects of colour and stimuli side were examined for the three measures. Stimuli side did not have a significant effect on any of the measures, but the colour did have an effect on response time (F(1,38)=4.20; p=.047; η²=.100); this is shown below in Figure 4.31. Post hoc test revealed that participants were faster at responding to the yellow stimuli (M=526; SE=18) than pink stimuli (M=539; SE=17).
This finding is likely to be due to the fact that the yellow circles had higher luminance than the pink circles, and therefore participants were faster at responding to the yellow circles due to higher stimulus saliency. As there were no main effects on errors, the luminance did not affect the participants’ ability to identify the colour of the circle. Although this could be a potential confound for the main experiment, the circle colours were counterbalanced in order to diminish this effect of luminance, and as reported later no effect of colour group was found. It does raise the point that, if this study were to be repeated, it may be better to match the colours for luminance more closely for stricter control.

The interaction between stimuli side and colour was found to be significant for both the proportion correct ($F(1,38)=5.42; \ p=.025; \ \eta^2=.125$) and response time measures ($F(1,38)=8.19; \ p=.007; \ \eta^2=.177$). These interactions are shown below in Figure 4.31, with the proportion correct graph on the left and the response time graph on the right. Post hoc t-tests revealed that there was a significant difference for the pink (but not the yellow) stimuli between left and right for both the proportion correct ($t(38)=-2.42; \ p=.021$) and the response time ($t(38)=2.38; \ p=.023$) measures. There was also a significant difference between yellow and pink stimuli when they were presented on the left ($t(38)=3.17; \ p=.003$) for the response time measure only. Participants were more accurate for pink stimuli presented on the right ($M=.983; \ SE=.006$) than for those presented on the left ($M=.955; \ SE=.008$); they were also faster at responding to pink stimuli on the right ($M=529; \ SE=17$) than when it was presented on the left ($M=550; \ SE=17$). This asymmetry may only be evident for the pink stimuli due to the effect of

![Figure 4.31. The effect of stimuli colour on response times](image-url)
the higher luminance causing the performance on the yellow stimuli trials to be at ceiling level, but with the lower luminance pink stimuli more subtle asymmetries become evident. The asymmetry shown here, with participants responding faster and more accurately to pink stimuli presented on the right of the visual field, is the opposite to the asymmetry demonstrated in the previous studies where performance was better for stimuli appearing on the left. However, this may be due to the nature of the stimuli as it has been shown that the categorization of colour is biased towards the right visual field in normal adults (Franklin et al., 2008).

Figure 4.32. The interactions between stimuli colour and stimuli side presented for the proportion correct (left) and response time measures.
4.2.2.1 Relationships with Schizotypy

The total scores on the SPQ were significantly related to the proportion of eye-movements made during the colour discrimination task \((F(1,37)=6.29; \ p=.017; \ \eta^2=.145)\). Post hoc correlations revealed that this was a positive correlation \((r(39)=.381; \ p=.017)\), which is shown below in Figure 4.33. This relationship was also significant for the disorganized factor and proportion of eye-movements \((F(1,37)=5.77; \ p=.021; \ \eta^2=.135)\), which was also revealed to be a positive relationship \((r(39)=.367; \ p=.021)\) and is also shown in Figure 4.33. When the figures are examined, it is clear that there are a large number of individuals who make either no or a very small number of eye-movements. Those making no eye-movements have a large spread of scores, including the highest scorer on the SPQ. Therefore, the samples were split into two groups, with all those with no eye-movements (24 individuals) in one group and those who made eye-movements (15 individuals), the SPQ and factor scores were then compared between the two groups using independent sample t-tests. Those who made eye-movements did not have significantly higher scores on the SPQ overall \((p=.102)\) or the disorganized factor \((p=.218)\). This finding suggests that the interpretation of this relationship should be taken with caution. There was, however, a significant difference between the two groups for the interpersonal factor \((t(37)=-2.05; \ p=.048)\), which should also be interpreted carefully as this relationship was not significant in the MANCOVA. Taken together there may be an effect of schizotypy scores on the ability to maintain fixation during this task, but it is not a consistent effect.

![Figure 4.33. The relationships between the proportion of eye-movements made and the total (left) and Disorganized Factor (right) Schizotypal Personality Questionnaire scores.](image-url)
There were no significant interaction between the SPQ scores and any of the independent variables.

4.2.2.3. The Classic Anti-Saccade Task

As there were no errors made in the pro-saccade task, there was a significant main effect of task type for the error measure \( F(1,39)=48.74; p \leq .0005; \eta^2=.556 \). This indicated that the participants made a significant number of errors on the anti-saccade trials \( (M=.215; SE=.031) \), when compared to the zero error performance in the pro-saccade trials. This is in line with previous research, which indicates that participants who are able to make reflexive saccades without error tend to make some reflexive errors when asked to complete anti-saccade trials (Hallett, 1978; Hallett & Adams, 1980).

There was also a main effect of trial type for saccade latencies \( F(1,25)=80.30; p \leq .0005; \eta^2=.755 \), which is shown in Figure 4.34, with larger latencies for the anti-saccade trials \( (M=214; SE=7) \) than for the pro-saccade trials \( (M=167; SE=4) \). This is in line with previous findings that participants have taken longer to respond to the anti-saccade trials than the pro-saccade trials (Hallett & Adams, 1980).

![Figure 4.34. The main effect of trial type on saccade latency](image)

When the correct trials and the incorrect trials were compared there was a significant difference for both saccade latencies \( (F(1,19)=42.28; p \leq .0005; \eta^2=.690) \) and saccade amplitude \( (F(1, 19)=5.45; p=.031; \eta^2=.223) \). The graphs for the main effects are show in Figure 4.35, indicate that saccade latencies (shown on the left) were longer for the trials with correct saccades \( (M=255; SE=10) \) than those with incorrect reflexive saccades \( (M=178; SE=8.22) \). For the saccade amplitudes (shown in the right-hand graph) there were larger saccades for the correct trials \( (M=9.61; SE=6.9) \) than for the
error response trials ($M=8.06; \text{SE}=0.26$). These findings are consistent with previous findings of shorter latencies and amplitudes for the error responses (Brownstein et al., 2003; Schaeffer et al., 2013; Weber, Durr, & Fischer, 1998).

![Figure 4.35](image.png)

*Figure 4.35. The difference between correct and error saccade responses for the saccade latency (left) and saccade amplitude (right) measures.*

There was also a significant main effect of side for the error measure ($F(1,39)=7.79; p=0.008; \eta^2=0.166$) as there were no errors for the pro-saccade task, as well as a significant interaction between stimulus side and trial type for the error measure ($F(1,39)=7.79; p=0.008; \eta^2=0.166$). Further analysis of this interaction, shown in Figure 4.36, revealed that for the anti-saccade trials participants made more errors when the stimuli appeared on the right hand side ($M=0.25; \text{SE}=0.032$) than when the stimuli appeared on the left hand side ($M=0.18; \text{SE}=0.036$). This asymmetry is a little harder to interpret than the one displayed in the colour discrimination task; however, it could be that participants need to move their eyes towards stimuli appearing on the side with poorer covert attention in order to process it.
There were no relationships between the schizotypy measures and the error rates. This is against the predictions of the study, as it was expected that there would be a positive relationship between schizotypy scores and the number of errors made on the anti-saccade task.

There was a significant interaction between the total scores on the SPQ and the trial type ($F(1,25)=5.87; p=.023; \eta^2=.19$) for the saccade latency measure. Post hoc correlations between the total SPQ scores and the difference between the two trial types (pro-saccade latencies – anti-saccade latencies) showed a negative relationship ($r(27)=-.436; p=.023$). These relationships are shown below in Figure 4.37, and they indicate that higher scoring participants showed a greater difference between saccade latencies for the different trial types, with larger saccade latencies for the anti-saccade trials than the pro-saccade trials. There was also a significant interaction between the cognitive-perceptual factor and trial type ($F(1,25)=7.33; p=.012; \eta^2=.227$). Post hoc correlations between the cognitive-perceptual factor and the difference between trial types also showed a negative relationship ($r(27)=-.476 p=.012$); thus, this followed the same pattern as for the interaction for the total scores. This finding suggests that individuals who scored higher on the SPQ and the cognitive-perceptual factor (representative of positive traits), when compared to their own baseline of pro-saccade latencies, were much slower responding to the anti-saccade trials. As individuals with a diagnosis of schizophrenia tend to have longer latencies for the anti-saccade trials, this finding appears to reflect this tendency for those who score higher on the SPQ and for the positive SPQ traits. It could also indicate a speed-accuracy trade off, where in previous
studies higher numbers of errors have been found in higher scorers (Holahan & O'Driscoll, 2005; O'Driscoll et al., 1998); here individuals may have reduced their errors by taking longer to respond to the anti-saccade trials.

![Graph](attachment:image.png)

*Figure 4.37. The relationships between the pro and anti-saccade trial differences for the saccade latency measure and the total scores on the SPQ (left) and the cognitive-perceptual factor scores (right)*

When only the anti-saccade trials were examined in the response type analysis, there was a significant effect of both the total SPQ scores ($F(1,18)=6.75; p=.018; \eta^2=.273$) and the disorganized scores ($F(1,18)=11.16; p=.004; \eta^2=.383$) for the saccade latency measures and these relationships are shown below in Figure 4.38. Post hoc correlations revealed that both the total scores ($r(20)=.522; p=.018$) and disorganized factor ($r(20)=.549; p=.004$) were positively correlated with the saccade latencies, with longer latencies relating to higher scores on these factors. This finding seems to be suggesting perhaps a longer processing time is needed for higher scorers on the anti-saccades, once again mirroring results for previous studies where longer latencies were found for individuals with a diagnosis of schizophrenia.
4.2.2.4. Main Anti-saccade Task

The data was initially analysed to check whether colour had an effect on performance, as it was found not to have any significant effects or interactions further analyses were conducted with the colour groups merged. Similarly, stimulus side was not found to be significant for any of the measures, nor were there any interactions found including this variable; therefore, further analyses were collapsed for stimulus side. This indicates that the differences found for the colour discrimination task for both stimulus side and colour did not seem to have impacted on the saccade response tasks, and was perhaps either an anomaly or specific to either the covert attention or the manual responses involved in the colour discrimination task.

The trial type variable was found to have a significant effect \( (F(3, 37) = 40.36; \ p \leq 0.0005; \ \eta^2 = 0.766) \); this was on both the proportion of saccade errors \( (F(1, 39) = 64.24; \ p \leq 0.0005; \ \eta^2 = 0.622) \) and saccade latencies \( (F(1, 39) = 8.59; \ p = 0.06; \ \eta^2 = 0.180) \). The post hoc analysis for the error rates revealed that there were higher proportions of errors for the anti-saccade trials \( (M = 0.386; \ SE = 0.03) \) than the pro-saccade trials \( (M = 0.107; \ SE = 0.01) \). The graphs in Figure 4.39 below show the difference between the error rates for the two trial types; although there were more errors for the anti-saccade trials overall, consistent with the classic anti-saccade trials, there were also significant saccade errors for the pro-saccade trials, which was not shown in the classic pro-saccade trials. This suggests that due to the intermittent presentation of trials, the anti-saccade trials also interfered with the pro-saccade response, which as a reflexive saccade should have been straightforward. The saccade latencies were found to be longer for the pro-saccade
trials ($M=276; SE=9$) than the anti-saccade trials ($M=264; SE=7$). It is clear that individuals had to process the stimuli for longer for both trial types when compared to the block presentations in the classic anti-saccade task, as the latencies were longer for both in this task. This particular difference indicates that for the pro-saccade trials the responses (which are mainly correct responses), were not just reflexive responses to the targets; rather the participants were taking longer to respond to these trials than the anti-saccade trials. This could be due to the suppression of the reflexive saccade responses which then had to be re-engaged once that participants had identified the required response.

There were also no main effects of task type found for any of the measures, suggesting that the dominance of either trial type gave no relative benefit on any of the performance measures. However, there was a significant interaction between trial type and task type ($F(3,37)=39.19; p\leq.0005; \eta^2=.761$), found for both the proportion of errors ($F(1,39)=106.26; p\leq.0005; \eta^2=.732$) and saccade latency ($F(1,39)=30.47; p\leq.0005; \eta^2=.439$). Post hoc t-tests for the errors revealed that, although there were significant differences between all the pairwise comparisons (shown in Table 4.14.), the difference between the errors for the pro and anti-trial in the pro-saccade task was the largest. This interaction, shown in Figure 4.40 on the left, indicates that generally, there were significantly more errors for the anti-saccade trials when these were compared within task. However, when the tasks were compared there were significantly more errors on the anti-saccade trials when the pro-saccade trials were

![Figure 4.39](image-url) The effect of trial type on the proportion of errors made (left) and the latencies of saccade responses (right).
dominant than when the anti-saccade trials were dominant. This was reversed for the pro-saccade trials. This is the predicted result, as there were errors on the pro-saccade task, which were increased for the anti-saccade task, where an anti-saccade was the most likely response required.

Table 4.14. Table showing the results of the post hoc tests t-tests for the trial type and task type interaction on the proportion of response errors measure.

<table>
<thead>
<tr>
<th></th>
<th>Difference between Trial types</th>
<th>Difference between Task types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-statistic</td>
<td>df</td>
</tr>
<tr>
<td>Anti-saccade Task</td>
<td>-3.21</td>
<td>39</td>
</tr>
<tr>
<td>Pro-saccade task</td>
<td>-7.69</td>
<td>39</td>
</tr>
</tbody>
</table>

For the same interaction on the saccade latencies, which is shown also in Figure 4.40, post hoc tests revealed that there was a significant difference between pro- and anti-saccade trials for the anti-saccade task only (t(39)=5.43; p≤.0005), with shorter latencies for anti-saccade trials (M=269; SE=6) compared to pro-saccade trials (M=285; SE=9). There was also a significant difference between the task types for the anti-saccade trials (t(39) =2.72; p=.01) with shorter latencies on the anti-saccade trials on the anti-saccade task (M=259; SE=6) than the anti-saccade trials on the pro-saccade task (M=271; SE=8). This result shows that when the dominant response required was the anti-saccade this made individuals take longer to respond to the pro-saccade trials; this could be because they were primed to make an anti-saccade response that then had to be changed to a pro-saccade response. However, if this was the case it would be expected that this pattern would be reversed for the pro-saccade task, but instead there
were no differences in latencies for the trial types. This lack of a difference could be due to the higher number of errors on the anti-saccade trials for the pro-saccade task, as error responses were found to be faster than correct response (see below), representing a speed-accuracy trade-off. As reported later there is an interaction between response type (error or correct), task type and trial type that supports this interpretation.

The trials for correct and error saccades were compared for the saccade latency and saccade amplitude measures. This revealed a significant difference between the trials with error responses and those with correct responses for both the saccade latency \( F(1,30)=108.88; p \leq .0005; \eta^2=.784 \) and saccade amplitude measures \( F(1,30)=53.40; p \leq .0005; \eta^2=.640 \). These findings, shown in Figure 4.41 below, indicate faster saccade latencies for the error trials \( (M=257; SE=9) \) than for the correct response trials \( (M=302; SE=10) \), as well as larger amplitudes for the correct responses \( (M=8.77; SE=.20) \) than for the error response \( (M=7.61; SE=.21) \) trials. This once again replicates earlier findings from other researchers (e.g. Massen, 2004), as well as replicating the findings from the classic anti-saccade task.

![Figure 4.41. The difference in saccade latencies (left) and saccade amplitudes (right) between the correct and error responses.](image)

There were also significant interactions between whether correct or error responses were made and trial type for both saccade latency \( F(1,30)=120.45; p \leq .0005; \eta^2=.801 \) and saccade amplitude \( F(1,30)=16.97; p \leq .0005; \eta^2=.361 \). Post hoc t-tests (the statistics are shown in Table 4.14) revealed significant differences between correct and error responses for both trial types for the saccade latency measure, but the difference between correct and error responses was only significant for the pro-saccade trials for the saccade amplitude measure. The interactions are shown in Figure 4.42; for the saccade latency measure (shown on the left) it shows opposing patterns in
relation to the trial types across the two response types. The largest difference for the saccade latency measure was between response types for the anti-saccade trials with much shorter latencies for the error responses than the correct responses, with the pro-saccade responses lying in between these two extremes. This interaction also supports the earlier interpretation that the shorter latencies for the anti-saccade errors were causing longer pro-saccade latencies on average across both response times, as shown in the main effect. However, once the correct responses were considered the anti-saccade trials had the longest latencies, supporting previous findings for the classic anti-saccade task of the difference between the anti-saccade error and correct latencies, as well as that shown in the background literature (e.g. Massen, 2004).

Table 4.15. *Post hoc t-test statistics for the pairwise comparisons for the interaction between response type and trial type for the saccade latency and saccade amplitude measures.*

<table>
<thead>
<tr>
<th>Difference between Trial types</th>
<th>Difference between Response types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saccade Latencies</td>
<td>Saccade Latencies</td>
</tr>
<tr>
<td>Correct Response</td>
<td>Error Response</td>
</tr>
<tr>
<td>t-statistic</td>
<td>p-value</td>
</tr>
<tr>
<td>9.24</td>
<td>39</td>
</tr>
<tr>
<td>-.974</td>
<td>39</td>
</tr>
<tr>
<td>Anti-saccade Trials</td>
<td>Pro-saccade Trials</td>
</tr>
<tr>
<td>6.86</td>
<td>39</td>
</tr>
</tbody>
</table>

For the saccade amplitudes measure, the biggest difference was between the amplitudes for the pro-saccade trials, where the correct responses had fairly accurate amplitude; those with error responses had much shorter amplitudes, suggesting that a realisation of an error may have been faster in the pro-saccade causing a quicker
cancelling of the incorrect saccade than for the anti-saccade errors. The error responses were also significantly different possibly due to the fact that the error responses for the anti-saccade trials were aimed at a target, whereas those for the pro-saccade were not. However, it could be argued that those where the target was coming into view should notice their mistake faster than when they were looking away from the target.

The most striking thing about the graphs in Figure 4.42 below is the way the error and correct responses more or less mirror one another, inferring that the error response are behaving like the correct responses of the opposing trial type, perhaps representing the fact the error was made higher up in the processing has led to an imitation of what was conceived to be the correct response.

Finally, there was an interaction between whether an error was made, task type and trials type that was significant for the saccade latency measure ($F(1,30)=34.55; p \leq .0005; \eta^2=.535$). This interaction, graphed below in Figure 4.43, shows that once the trials were split into the relative tasks this was consistent with the findings above. The differences between task type were significant for the correct responses for the pro-saccade trials ($t(39)=6.04; p \leq .0005$) and anti-saccade trials ($t(39)=-4.14; p \leq .0005$) as well as the pro-saccade trials for the error responses ($t(39)=-2.392; p=.023$) but there was no difference in latency for the error responses on the anti-saccade trials ($p=.248$) Although this is a complex interaction it shows that when the trial type was dominant in the task it enhanced the speed for the correct responses, and when they were discordant it slowed correct responses. The lack of task effect on the anti-saccade error responses supports the notion stated above that these errors could be due to reflexive eye-movements whose profile is not affected by task type, as there is no processing time prior to this type of response.
There were no main effects of the schizotypal measures on the proportion of errors, the saccade latency or saccade amplitude measures. This is against expectations, as it would be anticipated that the relationships shown between schizotypy and the saccade latencies from the classic anti-saccade task would be replicated here. It was also expected that some relationships between schizotypy and error rates would also be present, as this is a harder task and therefore more likely to highlight the more subtle deficits that could be present in a non-clinical sample. It may be that the added decision element in this experiment evened out the basic relationships found on the classic anti-saccade as more working memory and top down processing would be involved in this task, which perhaps is not relatively impaired in relation to schizotypy traits.

There was a significant interaction between the task type and the disorganized factor ($F(1,38)=4.98; p=.032; \eta^2=.116$) for the saccade latency measure. Post hoc correlations between the disorganized factor scores and the difference between saccade latencies for the two task types (anti-saccade task latencies – pro saccade task latencies) found a negative relationship between the two ($r(40)=-0.34, p=.032$). This indicates that those who scored higher on the disorganized factor had longer latencies in the blocks in which pro-saccades were the most common trial type. This was not in line with the expectations or findings from the classic anti-saccade task in which individuals with

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**Figure 4.43.** Interaction between the task type, trial type and response type for the correct responses (left) and error responses (right).

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### 4.2.2.4.1. Relationships with Schizotypy

There were no main effects of the schizotypal measures on the proportion of errors, the saccade latency or saccade amplitude measures. This is against expectations, as it would be anticipated that the relationships shown between schizotypy and the saccade latencies from the classic anti-saccade task would be replicated here. It was also expected that some relationships between schizotypy and error rates would also be present, as this is a harder task and therefore more likely to highlight the more subtle deficits that could be present in a non-clinical sample. It may be that the added decision element in this experiment evened out the basic relationships found on the classic anti-saccade as more working memory and top down processing would be involved in this task, which perhaps is not relatively impaired in relation to schizotypy traits.

There was a significant interaction between the task type and the disorganized factor ($F(1,38)=4.98; p=.032; \eta^2=.116$) for the saccade latency measure. Post hoc correlations between the disorganized factor scores and the difference between saccade latencies for the two task types (anti-saccade task latencies – pro saccade task latencies) found a negative relationship between the two ($r(40)=-0.34, p=.032$). This indicates that those who scored higher on the disorganized factor had longer latencies in the blocks in which pro-saccades were the most common trial type. This was not in line with the expectations or findings from the classic anti-saccade task in which individuals with
higher schizotypal scores would have longer latencies for anti-saccade trials. It seems to suggest that higher scorers actually took longer to respond when the pro-saccade trials were dominant, where they would be expected to make more errors on the anti-saccade trials as they were less common and this would have made errors more likely. Thus, it may be that in order to make fewer errors, individuals with higher disorganized scores were taking longer to process the stimuli to reduce their errors.

![Figure 4.44. Relationship between the saccade latencies for task type (anti-saccade – pro-saccade task latencies) and the Disorganized Factor Scores](image)

### 4.3. Experiment Two

#### 4.3.1. Method

#### 4.3.1.1. Participants

Twenty participants took part in this study, ten made up the schizophrenia group and ten the comparison group. The schizophrenia group consisted of a sub-group of the participants from in the experiments in the previous two chapters. All previous participants were approached but three declined to participate. Once again participants were all on anti-psychotic medication; two were taking typical antipsychotic medication (2 Flupenthixol) and eight were taking atypical antipsychotic medication (3 Respiridone, 3 Clozapine, and 2 Aripiprazole). For a breakdown of medication for participants see Appendix A. The comparison participants consisted of a group that were recruited through advertisements and posters displayed within the University and the wider community, as well as some participants from the two studies in the previous
chapters. The same exclusion criteria were also applied for this group as for the previous control participants. The demographic information for the participants is displayed below in Table 4.16. The table shows that participants did not significantly differ on age, gender or education level. However, they did significantly differ, once again, on their Wechsler Adult Intelligence Scale subtest scores.
Table 4.16. *Demographic Information for the Schizophrenia Outpatients Participants (SOP) and Healthy Control Participants (HCP)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>SOP (N=10)</th>
<th>HCP (N=10)</th>
<th>Statistical Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ±SD</td>
<td>Mean ±SD</td>
<td>df</td>
</tr>
<tr>
<td>Age (years)</td>
<td>40.8±5.92</td>
<td>38.2±6.43</td>
<td>18</td>
</tr>
<tr>
<td>Gender (male/female)</td>
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<td>7/3</td>
<td></td>
</tr>
<tr>
<td>Education Level (own/father’s)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pre-GCSE</td>
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<td>0/3</td>
<td></td>
</tr>
<tr>
<td>GCSE</td>
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<td>1/4</td>
<td></td>
</tr>
<tr>
<td>A-Level</td>
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<td>4/2</td>
<td></td>
</tr>
<tr>
<td>Degree</td>
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<td>4/0</td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
<td>2/0</td>
<td>1/1</td>
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</tr>
<tr>
<td>Ethnicity</td>
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<td>Chi-Square</td>
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<td>White British</td>
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<td>8</td>
<td></td>
</tr>
<tr>
<td>Indian British</td>
<td>4</td>
<td>0</td>
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</tr>
<tr>
<td>Hispanic</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mixed Race</td>
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<td>1</td>
<td></td>
</tr>
<tr>
<td>WAIS-IV Scores</td>
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<td></td>
</tr>
<tr>
<td>Block Design</td>
<td>9.20±2.78</td>
<td>13.60±2.17</td>
<td>18</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>7.60±3.34</td>
<td>12.00±1.94</td>
<td>18</td>
</tr>
<tr>
<td>Information</td>
<td>11.20±2.82</td>
<td>13.90±2.55</td>
<td>18</td>
</tr>
<tr>
<td>Coding</td>
<td>8.30±1.83</td>
<td>12.00±1.94</td>
<td>18</td>
</tr>
<tr>
<td>FSIQ-Estimate</td>
<td>93.30±14.45</td>
<td>121.30±9.44</td>
<td>18</td>
</tr>
<tr>
<td>BPRS</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Affect</td>
<td>8.40±2.88</td>
<td></td>
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<tr>
<td>Positive</td>
<td>6.00±2.54</td>
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</tr>
<tr>
<td>Negative</td>
<td>6.20±2.70</td>
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<td></td>
</tr>
<tr>
<td>Activation</td>
<td>4.00±1.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance</td>
<td>4.70±2.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>29.30±6.38</td>
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<td></td>
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<tr>
<td>Illness Duration</td>
<td>13.30±7.53</td>
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<tr>
<td>Medication Dose</td>
<td>538.75±262.63</td>
<td></td>
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</tr>
</tbody>
</table>

4.3.1.2. Design

The design for this experiment was very similar to the design for Experiment one in this chapter. The independent variables and dependent measures for the eye-tracking tasks were the same. The difference was that in this study the schizophrenia and comparison groups (detailed above) formed the between-participants measure and no schizotypy measures were used.

4.3.1.3. Materials and Apparatus

As the eye-tracking task in this experiment was the same as the one completed by the student sample the same stimuli, the same eye-tracking apparatus and set up was used. Further materials that were used were the Brief Psychiatric Rating Scale, and the
Block Design, Arithmetic, Information and Coding subscales of the Wechsler Adult Intelligence Scale. See chapter 2 for more detailed descriptions of these measures.

4.3.1.4. Procedure

Like in Experiment one in this chapter, participants first completed the classic anti-saccade task, then the colour discrimination and finally the main anti-saccade experiment, which were identical to the ones completed by the student sample. The participants in this experiment, however, completed the task over two hours, usually in two sessions with some of the WAIS subtests completed in at the end of each session for the control group, the individuals in the schizophrenia group had already completed these measures, along with the BPRS during participation in the studies in Chapters two and three. This was to accommodate the fact that the participants were less used to participating in experiments and generally took longer to complete this task; it also gave these participants in particular a chance to have more breaks (hence the two sessions) to reduce fatigue. They were given the practice trials for the main experiment again at the beginning of the second session as a reminder of the task.

4.3.1.5. Data Analysis

The data for this study was sorted in the same way as for Experiment one. After the exclusion criteria was applied this resulted in a proportion of .025 trials being removed for the colour discrimination task; with .077 and .054 being excluded for the classic anti-saccade and main anti-saccade experiments respectively. In the analysis of this study MANOVAs were again conducted for each of the tasks, but they also included the between-subjects variable of group (schizophrenia or comparison). MANCOVAs were also conducted for each of the tasks with the covariates of estimated IQ, and the four WAIS subsets (block design, arithmetic, information and coding) for the whole sample and the covariates of Drug dose (chlorpromazine equivalent), illness duration, BPRS total and BPRS affect, positive, negative, activation and resistance factor scores for the participants in the schizophrenia group only.

4.3.2. Results and Discussion

4.3.2.1. Colour Discrimination Task

In the colour discrimination task there was a main effect found of group on the proportion of eye-movements made ($F(1,18)=5.73; p=.028; \eta^2=.241$). This is shown
below in Figure 4.45, and indicates that the individuals in the schizophrenia group made a higher proportion of eye-movements ($M=.359; SE=.089$) than the comparison group ($M=.058; SE=.089$). This is consistent with the positive relationship between schizotypy scores and proportion of eye-movements in the student sample described above. This implies that there is an inability to inhibit eye-movements towards novel stimuli, even when the individuals are not primed to make an eye-movement, and that this is related not only to schizophrenia itself but also to traits distributed throughout the normal population that are related to the schizophrenia spectrum.

![Figure 4.45. The main effect of group on the proportion of eye-movements made](image)

There was no difference between the two groups on proportion correct or response time measures; the average proportion of correct responses for the schizophrenia group was .96 ($SE=.01$), and it was .98 ($SE=.01$) for the comparison group. The response times (in ms) for the button presses were 665 ($SE=74$) and 527 ($SE=22$) respectively, which, although there were not significant differences, clearly indicates that the schizophrenia group had a huge variation in their response times when compared to the healthy controls. There were also no significant interactions involving the group variable.

The main effects of stimuli side or colour were not significant for any of the measures, nor were there any significant interactions involving these variables. This, again is not consistent with the previous study; however, it means that colour should not affect the main experiment. The lack of an asymmetry may be due to the student sample having a larger sample size and not including a clinical group. This is supported by the previous studies in this thesis that have found more consistent asymmetries in the student sample.
Once the WAIS subtest variables were examined, along with estimated IQ, only the coding subtest had a significant effect on performance ($F(2,17)=3.75; p=.045; \eta^2=.306$), which was significant for the response time measure only ($F(2,17)=6.46; p=.02; \eta^2=.264$). Post hoc tests revealed that this was a negative correlation ($r(20)=-5.14; p=.02$), meaning that the higher scorers on this subtest had the fastest response times. This is expected, as the coding sub-scale is a measure of speed of processing and therefore should be related to how quickly the participants respond to the stimuli presented. The proportion of eye-movements made on this task also had significant relationships with Estimated IQ ($F(1,18)=7.44; p=.014; \eta^2=.292$), and the block design ($F(1,18)=5.40 p=.032; \eta^2=.231$) and the coding ($F(1,18)=6.44; p=.021; \eta^2=.263$) subscales. Post hoc correlations revealed negative relationships between the Estimated IQ ($r(20)=-.541; p=.014$), block design ($r(20)=-.513; p=.021$) and coding ($r(20)=-.480; p=.032$). These correlations are shown in Figure 4.46 below, and it is clear that they are influenced by a few low scorers who also made a lot of eye-movements. These low scoring participants were all from the schizophrenia group thus suggesting that this relationship is simply indicative of the effect of group on both proportion of eye-movements made and WAIS scores. However, there was a difference between the groups also on the information and arithmetic subsets, yet there were no significant relationships with those variables, indicating that there was a greater link between deficits on the coding and block design subtests and the inability to maintain fixation while responding to stimuli in the periphery.
There was no relationship between the BPRS or any of its factors and any of the measure in the colour discrimination task. Illness duration also did not have any relationships with the measures on this task.

Figure 4.46. The relationships between the proportion of eye-movements made during the colour discrimination task and the estimated IQ (top), block design (bottom left) and coding (bottom right) subscales.
There was a significant relationship between the drug dose measure and the response time measure ($F(1,8)=14.95; \, p=.005$), and a post-hoc test revealed this to be a positive relationship ($r(10)=.807; \, p=.005$) which is displayed in Figure 4.47. Therefore the participants who were on higher drug doses (based on calculated Chlorpromazine equivalents) had slower reaction times compared to those on lower doses. This finding could be representing the drug dose having an effect on reaction times, as has been reported before (Wezenberg et al., 2007), or it may indicate that those on higher doses had more severe problems which were currently controlled by medication and were therefore a direct effect of the underlying controlled condition.

![Figure 4.47. The relationship between the drug dose and response time measure for the schizophrenia group](image)

4.3.2.2. The Classic Anti-Saccade Task

There were no effects of, or interactions, involving group for the proportion of error or saccade amplitude measures. For this study it was expected that there would be a difference between groups on the proportion of error response made, with individuals in the schizophrenia group expected to make more errors than those in the comparison group particularly for the anti-saccade trials. The error rates were close to significant ($p=.071$) with the schizophrenia group having an average error rate of .43 ($SE=.41$) and the comparison group with an average error rate of .16 ($SE=.05$).

There was a main effect of group on the saccade latency measure one the correct and error rates were compared ($F(1,14)=5.87; \, p=.03; \, \eta^2=.295$). As shown in Figure 4.48 below, the schizophrenia group had longer latencies overall ($M=258; \, SE=15$) compared to the control group ($M=201; \, SE=13$). This result seems to be in line
with what was expected, as it shows that the schizophrenia group took longer to respond on the anti-saccade trials. However, it is worth noting that as not all participants made both error and correct responses this is an slightly smaller sample set (only 7 from the schizophrenia group and 9 from the comparison group).

There was a main effect of trial type ($F(3,17)=62.60; p<.0005; \eta^2=.917$) for both the proportion of errors made by participants ($F(1,18)=15.91; p=.001; \eta^2=.456$) and the latencies of their saccades ($F(1,18)=48.06; p<.0005; \eta^2=.791$). There were no errors in this sample for the pro-saccade trials compared with an average error rate of .296 ($SE=.074$) for the anti-saccade trials. For the saccade latency measure the difference between trials is shown in Figure 4.49, with longer saccades for the anti-saccade trials ($M=238; SE=9$) than for the pro-saccade trials ($M=178; SE=6$).

![Figure 4.48](image1.png)

*Figure 4.48.* The main effect of group on the saccade latency measure when the response type analysis was conducted.

![Figure 4.49](image2.png)

*Figure 4.49.* Main effect of trial type for the saccade latency measure
This is consistent with the student sample, which had exactly the same finding. It is also consistent with many previous studies (e.g. Barton et al., 2002) who found that participants generally took longer to respond on the anti-saccade trials when compared to the pro-saccade trials, as well as making errors on the anti-saccade trials. The fact that participants we able to do the pro-saccade trials correctly indicates that there are no fundamental problems with understanding instructions or the ability of the participants to orient their gaze towards novel stimuli when instructed to do so.

There was no main effect and no interactions involving stimulus side; although it is different to the findings of the student sample study, it is consistent with the findings in the colour discrimination task in the current study.

Once the trials where errors were made were compared with those that resulted in a correct saccade (collapsing over stimuli side) a significant difference was found between these trials for both saccade latencies ($F(1,14)=36.51; p \leq .0005; \eta^2 = .723$) and saccade amplitudes ($F(1,14)=16.24; p = .001; \eta^2 = .537$), shown below in Figure 4.50. This indicated longer saccade latencies ($M=258; SE=12$) and larger amplitudes ($M=10.28; SE=7.4$) for the correct saccades compared to the latencies ($M=191; SE=11$) and amplitudes ($M=7.89; SE=3.7$) for the error responses. This again replicates the findings from the student sample study where participants had shorter latencies and amplitudes for the trials when they made an error response.

![Figure 4.50](image.png)

*Figure 4.50.* The main effect of response type on the saccade latency (left) and saccade amplitude (right) measures.

When the WAIS-IV scores were used as covariates in the analysis of performance on the classic anti-saccade task, Estimated IQ ($F(1,18)=5.47; p = .031$);
and the Arithmetic ($\eta^2=0.233$) and Coding ($\eta^2=0.258$) subscales were all related to the number of errors made on the anti-saccade trials. Post hoc tests revealed that the Estimated IQ ($r(20) = -0.483; p = 0.031$), Arithmetic ($r(20) = -0.508; p = 0.022$) and Coding ($r(20) = -0.459; p = 0.042$) were all negatively related to the number of errors on the anti-saccade task, shown in Figure 4.51. Once the WAIS covariates were analysed separately for each individual group, there were no significant relationships found between these covariates and performance on this task. This could be due to the small sample size, as there were only ten participants in each group; however, it could also suggest that the relationship with the WAIS covariates across the whole sample was due to the difference in group scores on these variables. It also supports the role of working memory (represented by the arithmetic sub-scale) and speed of processing (represented by the coding subscale) in the anti-saccade task.

Figure 4.51. Relationship between the estimated IQ (top), arithmetic (bottom left) and coding (bottom right) subscales from the WAIS-IV and the proportion of error measure
When the drug dose was used as a covariate, in the form of the chlorpromazine equivalents, it was found to have a main effect on the saccade amplitudes ($F(8,1)=9.25; p=.016; \eta^2=.536$). Post hoc test revealed this to be a positive relationship ($r(10)=.732; p=.016$); the same positive relationship was found for the total BPRS scores ($F(1,8)=5.96; p=.040; \eta^2=.427; r(10)=.653$) and the positive factor of the BPRS ($F(1,8)=5.66; p=.045; \eta^2=.414; r(10)=.644$). These relationships are shown in Figure 4.52 below. Therefore those who scored higher on these measures had larger amplitudes than those who scored lower. As participants in general tended to make saccades that were short of the target location, it implies that actually the higher BPRS and positive factor scorers, and those on a higher dose of antipsychotic medication, were possibly more accurate with their eye-movements.

Figure 4.52. Relationships between the drug dose (top), Brief Psychiatric Rating Scale total (bottom left) and positive factor (bottom right) scores and the saccade amplitude scores
There was also a significant relationship between the negative factor scores on the BPRS and the saccade latencies measure ($F(1,8)=6.48; p=.034; \eta^2=.448$), which post hoc tests revealed to be a negative relationship ($r(10)=-.669; p=.034$), shown in Figure 4.53. Therefore, those who scored higher on this measure were actually faster in their responses than those who scored lower for the negative factor. This was the opposite to what would be expected, as those with more symptoms would be expected to have longer latencies, and thus have performance further from the comparison participants, than the lower scorers.

There were no other significant interactions or main effects with the covariates.

![Figure 4.53. Relationship between the negative factor scores and the saccade latency measure for the schizophrenia group](image)

### 4.3.2.3. Main Anti-saccade Task

First the sample was split into two groups based on the colour they were required to look towards. Consistent with the student sample findings, there was no main effect of colour found on any of the measures, nor were there any significant interactions found, so the groups were collapsed across colour. This was also the case for stimulus side.

There was a main effect of group overall ($F(3,16)=3.96; p=.027; \eta^2=.426$), which was found to be significant for the proportion of errors measure only ($F(1,18)=10.21; p=.005; \eta^2=.362$). This main effect, shown in Figure 4.54, represented more errors for the schizophrenia group ($M=.318; SE=.034$) than the control group ($M=.163; SE=.034$). This is in line with previous findings of higher errors in
individuals with schizophrenia when compared to the normal populations (Brenner et al., 2001; Brownstein et al., 2003; Franke et al., 2007; Maruff et al., 1998). The fact that a main effect of group on error responses was significant here but not in the classic anti-saccade suggests that this task may be more sensitive to subtle deficits that were not shown in the classic anti-saccade task, but that were present in this group.

In order to check that this effect was not related to the participants’ ability to judge the colour without moving their eyes the analysis was performed again with the proportion of eye-movements made on the colour discrimination task as a covariate. The effect of group on errors was still significant \( (F(1,17)=5.07; p=.038; \eta^2=.230) \), although it was reduced suggesting some of the effect of group was down to the inability to inhibit eye-movements towards the stimuli, there was also a significant differences once this was controlled for, thus showing there are other factors contributing to this group difference. There were also no significant relationships between the proportion of eye-movements and any of the measures on this task.

![Figure 4.54. Main effect of group on the error rates measure](image)

There was also a significant interaction between group and trial type \( (F(3,16)=3.77; p=.032; \eta^2=.414) \), which was found to be significant for the proportion of errors measure \( (F(1,18)=8.98; p=.008; \eta^2=.333) \). The interaction is shown in Figure 4.55, and represents that there was a significant difference between the two groups for the anti-saccade trials \( (t(18)=3.17; p=.008) \), but not for the pro-saccade trials \( (p=.923) \). This indicates that the schizophrenia group were able to perform the pro-saccade trials as well as the comparison group even when the trial types were intermixed, whereas the intermixing of the trials had a larger effect on the error rates in the schizophrenia group than the comparison group.
There was a main effect of trial type \((F(3,16)=20.88; p < .0005; \eta^2 = .797)\), which was significant only for the proportion of errors measure \((F(1,18)=46.98; p < .0005; \eta^2 = .723)\). The averages reveal that participants made fewer errors on the pro-saccade trials \((M = .062; SE = .011)\) than the anti-saccade trials \((M = .420; SE = .049)\), shown below in Figure 4.56. This main effect of trial type echoes the same main effect on the errors for the classic anti-saccade task, only for this task there were errors made on the pro-saccade trials, as well as a higher number of errors on the anti-saccade trials, suggesting that the pseudo-random mixed presentation had caused an increase in error rates for both trial types. This finding is also a replication of the main effect of trial type of errors found in the student sample.

![Figure 4.55](https://example.com/figure455.png)

*Figure 4.55. The interaction between the trial type and group for proportion of errors.*

![Figure 4.56](https://example.com/figure456.png)

*Figure 4.56. The main effect of trial type on proportion of saccade errors*
There was, however, an absence of the main effect of trial type on the saccade latency measure that was shown previously in the classic anti-saccade task; this suggests that the participants were taking as long to process the stimuli for the pro-saccade trials as for the anti-saccade trials. This might be due to the stimuli that signified the trial type being presented in the periphery during the trial, unlike previous experiments with intermittent trials where the trial type was signalled prior to the trial by a symbol presented in the centre of the screen (Barton et al., 2002; Hallett & Adams, 1980; Weiler & Heath, 2014).

There was also a significant interaction between trial and task type \(F(3,16)=6.45; p=.005; \eta^2=.547\), which was significant for the proportion of error measure \(F(1,18)=19.41; p<.0005; \eta^2=.519\). Post hoc pairwise comparisons revealed that there were significant differences between the trial types for each of the tasks and also for the task types for each of the trials (see Table 4.17 for the post hoc t-test statistics).

Table 4.17. *Table showing the results of the post hoc tests t-tests for the trial type and task type interaction*

<table>
<thead>
<tr>
<th></th>
<th>Difference between Trial types</th>
<th>Difference between Task types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-statistic df p-value</td>
<td>t-statistic df p-value</td>
</tr>
<tr>
<td>Anti-saccade Task</td>
<td>-3.71</td>
<td>19</td>
</tr>
<tr>
<td>Pro-saccade task</td>
<td>-7.27</td>
<td>19</td>
</tr>
<tr>
<td>Anti-saccade Trials</td>
<td>-3.32</td>
<td>19</td>
</tr>
<tr>
<td>Pro-saccade Trials</td>
<td>4.72</td>
<td>19</td>
</tr>
</tbody>
</table>

The interaction is shown in Figure 4.57. As a whole, the participants made more errors on the anti-saccade trials for both task types, but there was a smaller difference on the anti-saccade task, where there were relatively more errors on the pro-saccade task and relatively less errors on the anti-saccade task. The difference was larger between trial types on the pro-saccade task. This shows that in the dominance of trial types in the block had an effect on error rates, causing an increase for both of the trial types in relation to when they were the less frequent trial type in the block. This is in-line with the predictions for this task, as well being consistent with the student sample.
Differences between the correct and error responses were found in this experiment \((F(2,12)=21.44; p<.0005; \eta^2=.781)\); both for saccade latencies \((F(1,13)=34.63; p<.0005; \eta^2=.712)\) and saccade amplitudes \((F(1,13)=23.84; p<.0005; \eta^2=.657)\). These main effects, illustrated in Figure 4.58, indicated that participants had shorter saccade latencies \((M=252; SE=9)\) and smaller amplitudes \((M=8.23; SE=.27)\) for the error response saccades when compared to the saccade latencies \((M=286; SE=10)\) and the saccade amplitudes \((M=9.41; SE=.29)\) of the correct response saccades. Once again these findings were a replication of those found in the student sample, as well as those shown in previous studies. Generally for correct responses participants took longer to respond but made saccades that finished closer to the target location.

![Graph showing interaction between task type and trial type variables for error rates measure](image1)

**Figure 4.57.** Interaction between the task type and trial type variables for error rates measure

![Bar graph showing main effect of response type on saccade latency and amplitude](image2)

**Figure 4.58.** The main effect of response type on the saccade latency (left) and saccade amplitude (right) measures
There was also a significant interaction between trial type and whether a correct or error saccade was made for the saccade latency measure \( (F(1,13)=31.51; p<.0005; \eta^2=.692) \). Post hoc t-tests highlighted a significant difference between correct and error trials for the anti-saccade trials only \( (t(19)=10.67; p<.0005) \), but there was a significant difference between pro and anti-saccade trials for both the correct \( (t(19)=-6.17; p<.0005) \) and error \( (t(18)=5.64; p<.0005) \) responses. This interaction, shown in Figure 4.59, again replicates the same finding for the student sample, with participants faster for pro-saccade over anti-saccade trials for correct responses, but a reversal of this, with faster responses for the anti-saccade trials, when an error response was made. Once again the error responses are similar to the correct responses of the opposing trial type, perhaps indicating the error at the colour discrimination phase leading to the errors resembling what may have been perceived as a correct response. There was no replication of the findings from the student sample of the same interaction for the saccade amplitude measure; this may be due to different relationships (discussed later) in the schizophrenia group between the saccade amplitude measures and symptom scores and drug dose.

Figure 4.59. The interaction between the trial type and the response type measure for the saccade latency measure

Although there was not a main effect of group on the saccade latency measure, there was a significant interaction between the groups, the task type and whether a correct or error saccade was made for the saccade latency measure \( (F(1,13)=7.11; p=.019; \eta^2=.354) \). Post hoc tests revealed significant differences between correct and error saccades for both the anti-saccade task \( (t(9)=4.23, p=.002) \) and the pro-saccade
task \((t(9)=5.23; p=.001)\) for the comparison group. But, for the schizophrenia group there was only a significant difference for the anti-saccade task \((t(9)=4.34; p=.002)\) and not the pro-saccade task \((t(9)=2.15; p=.06)\). This interaction is shown in Figure 4.6.0 below and implies that for the schizophrenia group, the effect of response type on saccade latency diminishes for the pro-saccade task to the point where it is non-significant, perhaps indicating the relatively longer processing for the error responses on this task. However, when the graphs are examined there isn’t an obvious difference in pattern across the groups, in fact the graphs show that both groups follow the same pattern, with generally faster responses on error trials than correct trials, regardless of task type, this indicates that the majority of errors across task types were for the anti-saccade trials as these errors have shorter response latencies, whereas pro-saccade errors have longer latencies when compared to correct saccades.

*Figure 4.6.0. The interaction between the group, the task type and the response type; the graph on the left shows the task type and response type for the control group and the one on the right shows the same interaction for the schizophrenia group.*

When the estimated IQ and the subscales from the WAIS-IV were examined as covariates in the MANOVA, significant main effects were found on the proportion of errors for the Estimated IQ \((F(1,18)=7.22; p=.015; \eta^2=.286)\), and the Coding \((F(1,18)=5.27; p=.034; \eta^2=.226)\), Arithmetic \((F(1,18)=6.26; p=.022; \eta^2=.258)\), and Block Design \((F(1,18)=4.79; p=.042; \eta^2=.210)\) subscales. All of these were negative correlations: Estimated IQ \((r(20)=-.535)\), Coding \((r(20)=-.476)\), Arithmetic \((r(20)=-.508)\), Block Design \((r(20)=-.458)\).

Interactions between trial type and Estimated IQ \((F(1,18)=5.54; p=.03; \eta^2=.235)\), and the Coding \((F(1,18)=6.77; p=.018; \eta^2=.273)\) and Arithmetic \((F(1,18)=5.64; p=.029; \eta^2=.238)\) subscales were significant for the error measures. All
the covariates were negatively related to the number of errors made on the anti-saccade trials (Estimated IQ: $r(20)=-.517; p=.019$, Coding: $r(20)=-.508; p=.022$, Arithmetic: $r(20)=-.506; p=.023$). These relationships are shown in Figure 4.61 below, indicating that those with higher estimated IQ, arithmetic and coding scores, made fewer errors on the anti-saccade trials, but performance on the pro-saccade trials were unaffected by participants’ IQ scores. Therefore, in this sample, IQ, working memory (arithmetic) and speed of processing (Coding) were related to the ability to perform the anti-saccade trials correctly. This supports the role of working memory in this task, and also is consistent with the findings in the classic anti-saccade task with this sample.

![Figure 4.61. Graphs showing the relationships between the errors on the anti-saccade trials and the estimated IQ (top), the arithmetic subscale (bottom left) and the coding subscale (bottom right).](image)

Once the BPRS total and factor scores were analysed as covariates for relationships with the anti-saccade performance it was found that there was a significant relationship between the positive factor ($F(1,8)=7.31; p=.027; \eta^2=.478$) and the saccade amplitudes measure. A post hoc correlation revealed that this was a
positive relationship \((r(10)=.691; \ p=.027)\). There was also a main effect of drug dose, measured by the chlorpromazine equivalents, on the saccade amplitudes \((F(1,8)=6.90; \ p=.03; \ \eta^2=.463)\), which again was a positive relationship \((r(10)=.680; \ p=.03)\). These relationships are shown below in Figure 4.62. These are consistent with the findings on the classic anti-saccade task, where these relationships were also shown between the saccade amplitude measure and the drug dose and positive factor covariates. Although it is a little hard to interpret in terms of a clear deficit, it seems that there is a consistent effect of both symptomology and drug dose on the nature of the participants’ eye-movements in the schizophrenia group.

Finally, there was also a significant interaction between the resistance factor and task type for the saccade amplitudes measure \((F(1,8)=6.99; \ p=.03; \ \eta^2=.466)\). Post hoc tests assessed correlations of the resistance factor with the difference between participants’ saccade amplitudes for the pro- and anti-saccade tasks (pro – anti task). This highlighted a significant negative relationship between the two \((r(10)=-.683; \ p=.03)\), shown in Figure 4.63, with those with higher resistance factor scores having larger amplitudes on the anti-saccade task, and those with lower resistance factor scores having larger amplitudes on the pro-saccade task. Thus, the lower scorers were more accurate on the pro-saccade task, which is the performance that would be expected as the dominant pro-saccade trials had a physical target to aim the saccades; therefore the higher scorers are behaving in a more abnormal way. However, the main aspect this highlights, once again, is the variation of the saccade amplitude measure within the schizophrenia group and the relationship of this to symptoms displayed in this group.

Figure 4.62. Graphs showing the main effects of drug dose (left) and the BPRS positive factor (right) scores on the saccade amplitude measures.
4.3.2.4. Comparison of performance on the Classic and Main anti-saccade task

In order to look at the difference between error and latency performance across the anti-saccade trials for the classic version of the anti-saccade task and the main anti-saccade task as well as whether group interacted with this, an ANOVA was conducted with group and task type (in this case classic vs main anti-saccade tasks) as the independent variables. Overall there was a main effect of group on the error measure ($F(1,18)=6.79; p=.018; \eta^2=.274$) but not on the saccade latency measure ($p=.966$). There was also a main effect of task type (classic vs. main anti-saccade) on both the error ($F(1,18)=6.99; p=.016; \eta^2=.280$) and saccade latency measures ($F(1,18)=57.63; p<.0005 \eta^2=.762$), with longer latencies and more errors on the main task when compared to the classic task. However, there was no task (main vs classic) x group interactions for either measure. This suggests that although the individuals in the schizophrenia group were making more errors overall this was not affected by the added demands involved in the main experiment. Therefore, the error difference found appears to be a basic deficit and it is not made worse by increasing demands on working memory or having more complex instructions and task demands.

Figure 4.63. Graphs showing the interaction between the resistance factor scores from the BPRS and the task type for the saccade latency measure.
4.4. Overall Discussion

4.4.1. Effect of Schizophrenia and Schizotypy

4.4.1.1. Number of Saccade Error Responses

In the classic version of the anti-saccade task, individuals in the schizophrenia group did not differ from the control group in relation to the number of errors. In previous studies increased errors have been shown in individuals for similar experiments (Allen et al., 1996; Barton et al., 2008; Brenner et al., 2001; Brownstein et al., 2003; Curtis et al., 2001; Franke et al., 2007; Maruff et al., 1998; McDowell et al., 2002; N. Smyrnis et al., 2004). Although a higher error rate was expected in this group on the classic task, there was a higher error rate on anti-saccade trials in the main experiment; therefore it is clear that this group had an underlying deficit in completing this task. It may be that a task with higher cognitive demands highlighted the underlying deficit that was not apparent in a simple version of the anti-saccade task. However, it appears that for the classic task there were some individuals with significantly higher error rates in the schizophrenia group, and there were also some individuals who performed well, as indicated by the almost significantly higher error rates in the schizophrenia group who had a very large variation in scores. This is actually similar to the findings of Fukushima et al. (1988), who also did not find an overall difference between the schizophrenia group and control group in their study, but
instead found that some individuals differed significantly. Therefore, this basic deficit may be present in some individuals diagnosed with schizophrenia but it does not appear to be fundamental to the disorder.

There were no relationships between the Schizotypy Personality Questionnaire or any of its factors and error responses on either of the anti-saccade tasks. This was against expectation, as the previous studies into schizotypy had found a higher proportion of errors in those who score higher on schizotypy measures, especially in relation to positive traits. The lack of relationship between error rates and schizotypy in this study could be due to several factors; firstly the schizotypy measure used in the current study (the SPQ) differed from that used in the majority of previous studies, who tended to use the Perceptual Aberration Scale (PAS). Thus, it may be that errors are specifically related to the dimensions measured by the PAS and not the SPQ. It may also be that the analysis in this study used the continuous variable of SPQ scores, whereas previous studies tended to compare individuals who score very highly on schizotypy measures to those who are within the normal range. The reason a continuous score was used in this study was to look at whether deficits are continuous in relation to the schizotypy scores and therefore theoretically the schizophrenia spectrum. As a relationship was not found it would imply that increased errors are specific to higher scorers rather than covariant across the range of schizotypy scores. The final reason no errors may have been found could be due to the fact that these were negated by the variation in latencies that were found instead.

4.4.1.2. Saccade Latencies

When the saccade latencies were analysed there were some consistent findings in relation to the schizotypy measure and differences between the schizophrenia and comparison group. For the classic anti-saccade task individuals in the schizophrenia group showed longer latencies on the anti-saccade trials, and there were significant relationships between the total SPQ scores, the cognitive-perceptual (representing positive symptoms) and disorganized factor scores and the saccade latency measure. This was indicative of higher scorers having longer latencies on the anti-saccade trials. This finding is consistent with previous findings in individuals with a diagnosis of schizophrenia who tend to have longer latencies for the anti-saccade trials in particular (Barton et al., 2002; Curtis et al., 2001; Franke et al., 2007; Klein et al., 2000; Maruff et al., 1998; Muller et al., 1999) as well as abnormalities in performance on the anti-
saccade task being related to positive schizotypy traits (Holahan & O'Driscoll, 2005; O'Driscoll et al., 1998). However, this effect on saccade latency was not present for schizotypy or schizophrenia in the main anti-saccade study. It appears this may have been due, at least in the schizophrenia group, to a speed accuracy trade-off. In the classic anti-saccade task the schizophrenia group did not exhibit significantly more errors, but they were taking longer to respond, thus, in this simpler version of the task they were able to diminish the difference in error rates by taking longer processing time. However, when the task became harder and they were required to process stimuli in the periphery before responding, they no longer had latencies that were larger than the comparison group, but their error rate increased instead.

Why the latency relationship disappeared for the schizotypy study is harder to understand, as the harder task would be expected to increase this effect. Although in the main anti-saccade experiment there was an interaction between the disorganized factor and task type for saccade latencies, this was a weak relationship that did not relate to predictions. However, in the main task the latencies for the pro-saccade trials were no longer shorter due to the nature of the top down processes required for both trial types, therefore it may be that this change in nature of the task diminished the saccade latency difference in relation to the schizotypy score.

4.4.1.3. Eye-movements on the Colour Discrimination Task

One of the most robust relationships schizophrenia and schizotypy found was with the number of trials where participants made eye-movements towards the target during the colour discrimination task. For the schizotypy study there were significant relationship between the number of eye-movements made and the total SPQ, as well as the disorganized factor. In the second study there was a significant difference in the number of eye-movements made between the schizophrenia and comparison group. These findings together suggest that there is a difficulty inhibiting a reflexive response to a stimulus even when an eye-movement response is not required at all, and participants are only required to maintain fixation. This is consistent with the findings of Brenner et al. (2001) and Fukushima, Fukushima, et al. (1990) suggesting that at least some of the increase in errors for the schizophrenia group may be due to this inability to suppress orienting towards the peripheral stimuli. However, there was no relationship between errors in either of the anti-saccade tasks and schizotypy, suggesting that this inability to inhibit reflexive responses and maintain fixation may be
more closely linked to the schizophrenia spectrum than the anti-saccade deficits themselves. When these eye-movements were used as a covariate on the main task in experiment two, there was still an effect of group on error. This suggests the error rate in the schizophrenia group is not just down to the inability to suppress reflexive errors and is supported by the fact that the group also made pro-saccade errors on the main task, meaning they looked away from the target in error as well as making reflexive errors.

4.4.1.4. Saccade Amplitudes

There were also several relationships between drug dose and also symptom scores on the BPRS and the saccade amplitude measure within the schizophrenia group. These appear to show that individuals with lower drug doses and also less current symptoms were making smaller saccade responses and those with higher drug doses and displaying more symptoms were making larger saccade responses. This actually meant that those on higher drug doses and displaying more symptoms were more accurate with their initial saccade than the other participants. Although this finding is from a small sample, it is consistent across the classic and main anti-saccade studies, and therefore suggests that more studies should analyse saccade amplitude responses within the schizophrenia group to see if there is co-variation with other measures, as it is this large variation in the schizophrenia group that may mitigate any differences found when they are compared to a control group. It also appears to imply a large variation in this group for motor control, with some going beyond, and others falling short of the target area, once again highlighting the heterogeneity of abilities within this group.

4.4.2. Interpretation of the Main Anti-saccade Experiment

As well as looking into the ability to execute anti-saccades in relation to schizotypy and schizophrenia, this study was set up in order to create a new task that increased the inhibition and working memory load. This was done by putting an emphasis on working memory (in the discrimination of the target colour and making a response choice on a trial-by-trial basis) and making the need to maintain fixation in the centre more important, thus increasing inhibitory requirements. The increased difficulty of the task in comparison to the classic anti-saccade task was shown by the increase in errors for both trial types; this meant that there were also errors on the pro-saccade trials where previously there had been none. Furthermore, the saccade
latencies for the pro-saccades were also increased, indicating that the demands in this task changed the nature of the pro-saccade responses from reflexive responses (which have short latencies) to responses that required top down control.

The performance on the main experiment also replicated the two samples’ results for longer latencies and amplitudes for correct responses over error responses, as well as consistent relationships with the WAIS scores across the classic and main anti-saccade studies in experiment two. This supports the assertion that the classic anti-saccade and the main anti-saccade experiment are measuring the same underlying abilities.

The current study was also interested in whether individuals could switch strategy based by utilizing the information about the dominant response required in the task type. Both samples switched strategy to some degree across the tasks where either the anti- or pro-saccades were dominant. This was shown by the increase in errors relative to when the trial type was the less common in the task; so that the errors on the anti-saccade trials were higher in the pro-saccade task and the pro-saccade errors were also higher on the anti-saccade task. However, the underlying anti-saccade deficit was still evident as there were still more anti-saccade deficits across both task types. The presence of the pro-saccade errors also indicate that reflexive errors, where the participant is unable to inhibit an automatic response to the target, are not the only errors made by participants; as errors on the pro-saccade trials involved participants orienting away from the target. This increase in errors, along with the relative increase in latencies indicates that the pro-saccade trials in the main experiments were changed from a reflexive orienting to a top down process. As individuals with schizophrenia did not have more errors on the pro-saccade trials, when compared to the comparison group this suggests that they were able to use top-down control on these trials as well as the control group did. Therefore, the group difference was perhaps more related to the lack of inhibition for anti-saccades than top-down control in general. The fact that there are more errors on the anti-saccade trials suggests that a combination of mistake errors and reflexive errors occur to make the difference between the two, and reflexive responses on pro-saccade trials will be registered as correct even though the participants may not have processed the stimuli. Interestingly there were no interaction between group, trial type and task type, suggesting that the schizophrenia group also managed to switch strategies; as they did not show significantly different patterns between trial types across tasks. Therefore, like in the anti-cue task in the previous chapter, the
schizophrenia group were using the correct strategies, but their performance was just
poorer for the anti-saccade trials.

The mirroring of the saccade latencies and amplitudes (only for the student
sample) error and correct responses also supports this idea of mistaken responses, as the
error responses followed the same pattern as the opposing correct responses, suggesting
that participants may have initially responded as if they were correctly making the
opposing response. This is especially evident in the pro-saccade errors, as the latencies
for these were longer than the correct responses for both samples, suggesting longer
processing of the stimuli, yet the error was still made.

Thus, the main anti-saccade task appears to have been successful in looking
deeper into participants strategies on the anti-saccade task, but it did not reveal any
further group differences than the basic difficulty shown by individual with
schizophrenia in performance on anti-saccade trials in general.
Chapter Five
Discussion of Thesis

5.1. Summary and Overview

In this thesis there were three main experiments conducted, a traditional covert cueing task (with more valid than invalid cues) and an anti-cue version (with more invalid than valid cues), both of which involved the judgement of the presence of a target (presented on 50% of trials), and an anti-saccade experiment that involved a classical block version and an mixed block (pro and anti-saccade trials) task with peripheral colours signalling the trial type. For each of these experiments there were two samples that completed them; the first was a sample of students who were assessed for schizotypal traits, with these scores used as covariates in the analysis. The second sample included two groups, one made up of individuals diagnosed with schizophrenia, and the other was made up of age-relevant comparison subjects. The main aim of this thesis was to investigate the attention pattern differences that were present for the participants with a diagnosis of schizophrenia, and whether these differences extended into the normal population in relation to schizotypal traits.

In Chapter two for the cueing study the individuals in the schizophrenia group were poorer at discriminating the target (across d’ and hit rate) and slower at responding than the control group. There were also some relationships between schizotypy and hit rate, with higher scorers having lower hit rates. However no differences or relationships between schizotypy or schizophrenia and the strategic measures (cue weighting and λ) were found, and none of the students, the community participants nor the schizophrenia group used the cue information optimally. The participants across the two samples also showed an asymmetry, with better performance for the left visual field.

In Chapter three for the anti-cue study the individuals in the schizophrenia group were again slower at responding and had a significantly lower d’, but this difference was diminished, and there was no longer a significant difference between the two groups on hit rate. Again the schizophrenia group did not differ on the strategic measures, and their attention patterns indicated that they were able to switch to voluntary control of attention. In this study participants overall were able to use the cue information to their advantage, and they again showed the left visual field advantage.
In Chapter four both the schizophrenia group and those who scored higher on the schizotypy measure showed longer latencies for block presentations of anti-saccade trials as well as poorer inhibition of eye-movements on the colour discrimination task. On the main anti-saccade task the schizophrenia group showed more errors on the anti-saccade trials but not the pro-saccade trials; however, there were no differences on errors in relation to schizotypy. All the participant groups were also able to adapt their strategies for the task type, meaning that they made comparatively more errors on the task where the trial type was less frequent, than on the task where it was the dominant type, and this was the case for both pro- and anti-saccade trials.

These results revealed the following main themes: firstly, the individuals in the schizophrenia group did not differ on strategic approaches to any of the task to the comparison group. Secondly, the individuals with a diagnosis of schizophrenia did show some degree of impairment across all three of the tasks, but the relationships with schizotypy were less consistent. Thirdly, there were consistent findings for a left-visual field bias across the covert attention studies, but this was for the samples as a whole and not in relation to schizophrenia specifically. These main findings will be discussed with reference to previous findings, with suggested interpretations and some further research areas. This is followed by a discussion of the limitations and issues presented by the research in this thesis and some concluding comments.

5.2. Discussion of Main Findings

5.2.1. Performance in Individuals Diagnosed with Schizophrenia

5.2.1.1. Preserved Strategic Ability

Across all three of the experiments the participants that made up the schizophrenia groups did not differ significantly in terms of strategy from the comparison group. For both the cueing and anti-cue experiments there were no group effects on either the cue weighting measure, which indicates how much they used the cue validity information, or the criterion measure, which indicates how biased they were to either response (target present/target absent). Thus, suggesting they were not relying more heavily on one response than the comparison group and they were using the cue validity information in the same way as the comparison group as well. In the cueing experiment in Chapter two, they did not strategically use the cue information
that was provided, but neither did the comparison group nor the student group; the reasons for this are discussed below in the ‘limitation and issues’ section. Therefore, although they were behaving sub-optimally, they were not behaving differently from either of the non-clinical groups. For the anti-cue study they did use the cue information successfully and, like both the students and the comparison subjects, they responded more quickly to the target on the more common invalid trials. This is the opposite to the findings by Maruff et al. (1998) who found individuals with a diagnosis of schizophrenia did not respond faster for invalid cue, even when they were indicative of target location. Therefore, inability to inhibit reflexive orienting in covert attention is not consistent for all schizophrenia samples. The schizophrenia group also had a higher hit rate for the invalid trials, indicating that the focus of attention on the un-cued location also affected target perception, with more targets correctly perceived at the non-cued than the cued location. Thus, they were able inhibit or minimize the reflexive attention orienting towards the cue and voluntarily direct their attention to the opposing side.

In the main experiment in the third chapter both the individuals in the schizophrenia group and the comparison group made more errors where the pro- and anti-saccade trials were intermixed. However, the individuals in the schizophrenia group were not more affected than the control group by the higher demands in this task, as both groups showed the same increase in error rate from the classic version of the anti-saccade task. As the main task involved a higher working memory load, due to the judgement of colour forming the basis of responses, it suggests again that participants were as able as controls to process the more complex information and respond accordingly. This group also did not show any more impairment, either in terms of error rates or saccade latencies, on the pro-saccade trials in the main task, which due to the nature of peripheral colour stimuli indicating the required response were now controlled by a top-down process. This suggests that the deficit in schizophrenia group is more specific to anti-saccade processes and not just saccades that are voluntarily controlled. Furthermore, both groups, and the student sample, managed to adapt to the tasks based on the more likely trial type, with relatively fewer errors for each trial type on the task where they were more frequent when compared to the task where they were the less frequent trial type. This implies that the individuals with schizophrenia were able to use the frequency information, like in the anti-cue task, and adapt their performance for the more likely response type.
Therefore, this thesis seems to suggest that participants diagnosed with schizophrenia have preserved ability to use stimulus information in order to voluntarily move their attention focus both within the visual field and for eye-movements.

5.2.1.2. Impaired Performance and Response Times

There was a clear impairment of performance in the individuals diagnosed with schizophrenia for the cueing study in Chapter two, where they were slower at responding, poor at discriminating the target and poor at correctly identifying the target. The slower response times in this group is consistent with the previous findings on the COVAT, as many of these highlighted response time deficits for this group (Bustillo et al., 1997; Carter et al., 1992; Liotti et al., 1993; Posner et al., 1988). The accuracy adds to the current literature on the COVAT, as it indicates that not only are participants slower at moving their attention around the visual field, but they are also poorer at correctly interpreting information when attention is divided between two locations. This could be interpreted as either these participants being poor at shifting their attention or difficulties within this group on contrast discrimination due to the target and the pedestal differing on contrast. Indeed, some researchers have noted reduced contrast sensitivity in individuals with schizophrenia for presentations of low frequency gratings (Kantrowitz, Butler, Schecter, Silipo, & Javitt, 2009). In a future study, the underlying mechanisms used by the schizophrenia group to judge the presence of a target could be explored by employing techniques where the non-target stimuli are varied systematically in order to get a clearer idea of the decision criteria being used by these participants. This could be done through classification image analysis, which had been previously used to assess both normal observers (Eckstein et al., 2002) and those with neglect syndrome (S. Shimozaki, Kingstone, Olk, Stowe, & Eckstein, 2006).

This poorer attention shifting could be a candidate for underlying hallucinatory behaviour; as these individuals are slower at orienting their attention to novel stimuli and they are poorer at interpreting the information when they do so, this may cause them to misinterpret stimuli resulting in perceived hallucinations. If this finding was extended to auditory stimuli, and at least one study has shown orienting problems are consistent across vision and audition (Abbott et al., 2012), it would be more directly implicative, as auditory hallucinations are more common in individuals diagnosed with schizophrenia. Although there was no significant relationship between d’ and positive symptoms in the schizophrenia sample, there was a significant relationship in the
cueing study with cognitive-perceptual factor scores and schizotypy. Therefore in the non-clinical sample at least, positive schizotypy seems to have some relation with ability to interpret information when attention is divided across stimuli in the visual field.

5.2.1.3. Inhibition Deficits and Anti-saccade Errors

In the fourth chapter the onset of saccade responses were significantly longer for the schizophrenia group, and latencies were also related to schizotypy scores, with higher scorers displaying longer latencies. The schizotypy scores were related to positive and disorganized traits, which is supportive of anti-saccade deficits being related to positive schizotypy traits. However, previously individuals with higher numbers of positive traits exhibited more errors but no longer latencies. The longer latencies suggest that individuals with higher schizotypy scores and those in the schizophrenia group required more time to inhibit the reflexive response and then implement a correctly directed saccade; thus longer processing of top down attention control compared to controls and lower schizotypy scorers.

Individuals with schizophrenia also showed a basic inability to inhibit eye-movements to the peripheral stimuli on the colour discrimination task, and this was found to be consistent in relation to schizotypal traits as well. This suggests that there is a basic deficit in inhibition in schizophrenia and across the spectrum of this disorder. This supports and extends the previous findings of inhibitory problems in this group shown by previous researchers (Brenner et al., 2001; Fukushima, Fukushima, et al., 1990). However, this lack of inhibition did not account for all of the group differences in the main anti-saccade experiment between the schizophrenia and control group, suggesting that there is more to anti-saccade deficits than just the deficit in inhibition to the periphery stimuli.

5.2.1.4 Impairment in relation to schizotypy

The clearest attentional impairments in relation to schizotypy were the two findings discussed above of increased saccade latencies for anti-saccade trials in the classic anti-saccade task and the relationships between the ability to inhibit eye-movements and schizotypy on the colour discrimination task.

However, there were also several other relationships between the schizotypy scores and performance on the covert attention measures but these were less consistent.
In the study in Chapter two there was a relationship between both the cognitive-perceptual and total SPQ scores and hit rate for the lower contrast level, which suggests that there was some degree of general impairment in performance in relation to schizotypy scores for the cueing task. However, this was not replicated in the anti-cue task, so it seems this is not a consistent deficit and was likely to be related to the double (neutral) cue used in chapter two. In the anti-cue study there was also a relationship between the disorganized factor and cue side for the ability to discriminate the target. This appears to indicate that those who scored higher on this measure were showing a consistent deficit for right cues (when compared to the response times for the sample), whereas lower scorers were exhibiting a speed accuracy trade off, with faster responses for left cues, but better accuracy for right cued trials. This finding of a right-visual field deficit is consistent with the right visual field deficit found in previous studies with individuals diagnosed with schizophrenia (Carter et al., 1992; Maruff et al., 1995; Posner et al., 1988). Also, it was not connected to negative traits, which also fits in with Bustillo et al. (1997), who indicated the asymmetry was not present in those who score higher on negative traits. However, it is not consistent with the schizophrenia group in this study.

In terms of the schizophrenia spectrum, this thesis has provided some support for basic inhibition deficits when the maintenance of fixation is required, as well as some deficits in the basic control of eye-movements varying with schizotypy traits and being present in individuals with schizophrenia. But the evidence of deficits in covert attention was less consistent between schizotypal traits and the schizophrenia group’s performance, suggesting that eye-movement (overt attention) abnormalities may be more closely linked to this spectrum than covert attention performance.

5.2.1.5. Relationships between Symptom Scores, Drug Dose and Attention

For the schizophrenia group there were also several relationships between attention performance and the symptom scores on the Brief Psychiatric Rating Scale (BPRS). For the cueing study there was an asymmetry that was related to both the total BPRS score and also the affect factor scores, with a right visual field advantage for the higher scorers. Although this was an asymmetry it actually was closer to the comparison participants, who also showed the right visual field advantage. In the anti-cue study there was a relationship between the affect factor and the criterion measure,
with those scoring higher on this factor showing less bias than those who scored lower, who were more biased to respond target present. These findings together actually suggest that individuals with higher amounts of affect scores are performing more in line with the comparison participants, thus, potentially supporting the findings of Bustillo et al. (1997), where individuals with more ‘deficit’ symptoms, including negative affect, were less asymmetrically impaired than those with less of these symptoms.

In the anti-saccade studies there were consistent relationships between the chlorpromazine equivalents (drug dose) and measures on all three of the tasks. The first relationship was between drug dose and response times for the colour discrimination task, with higher drug doses related to slower responses. This is the opposite to several studies, which have found that individuals diagnosed with schizophrenia who are given anti-psychotic medication actually improve on measures of reaction time (Galletly, Clark, McFarlane, & Weber, 2000; Plesnicar, Zalar, Tomori, & Krajnc, 2003). It could be that this effect of drug dose on response time may be representing the underlying deficits, as the doses may be correlated with the level of the underlying illness, so a higher dose is likely to represent worse underlying deficits.

There were also significant positive relationships between both the drug dose variable and the BPRS positive factor scores for the saccade amplitude measures that were significant across the two anti-saccade tasks. This suggests that both positive symptoms and drug dose are related to the execution of eye-movements, specifically the amplitude of eye-movements. Highlighting the importance of examining saccade amplitudes and suggesting that this is an area for further research; it would be interesting to see if this could be replicated with a larger sample thus implying differences in motor control of eye-movements within schizophrenic groups varying with symptomology and drug doses.

5.2.2. Asymmetry Performance across Groups

There was a consistent asymmetry on the response time measures found across the two covert attention studies, which indicated a left visual field advantage. In the cueing study in Chapter two the student sample and the comparison group were both faster at responding to left visual field stimuli; however, the schizophrenia group did not show this asymmetry. In the anti-cue study in Chapter three, individuals again showed a left visual field advantage, demonstrated by response times that were fastest
when the participants responded to targets in the left visual field which were preceded by right-sided cues; this was consistent for all three groups. For the student sample the invalid trials with left targets and right cues also had the highest hit rates, showing that in a normal sample the asymmetry was also evident in performance as well as response time. This asymmetry is the opposite to that found in the control groups for some previous studies measuring response times on the COVAT, where they found a right-visual field advantage, which they related to the dominance of right-handed participants (Gouzoulis-Mayfrank et al., 2007; Moran et al., 1992; Strauss et al., 1992; Strauss et al., 1991). However, this bias, particularly in response to the invalid trials with right cues, is the same bias shown in the previous studies with individuals diagnosed with schizophrenia who were not on medication (Carter et al., 1992; Maruff et al., 1995; Posner et al., 1988), but in the current thesis this asymmetry was not related to schizophrenia and instead was most consistent in the student sample. As the student sample was effectively a fairly large non-clinical sample (larger than most control groups used in previous studies), this finding suggests that in the normal population there is a left-visual field bias, particularly when attention switching is required. Thus, the un-medicated individuals with schizophrenia in the previous study could be viewed as actually showing a normal pattern, but perhaps just an exaggerated one, as they showed the asymmetry in a small sample, yet the control group didn’t.

The left-visual field bias demonstrated in the covert studies in this thesis is also consistent with the line bisection studies, where individuals from the non-clinical population showed significant left-ward biases (Jewell & McCourt, 2000; McCourt & Olafson, 1997; Mennemeier et al., 1997; Scarisbrick et al., 1987). This bias is suggested to highlight the role of the right hemisphere in the control of covert spatial attention (Posner & Petersen, 1990). Therefore, the participants in the covert orienting tasks in this thesis appear to be showing this right parietal (and therefore left-visual field) dominance for attention processing. The implications of this are that as generally individuals are better at attending to the left-visual field, with a slight deficit for the right visual field, this should be accounted for by presenting more important information on the left, especially when items are presented on both sides of the visual field.

5.3. Limitations and Issues in this Research
5.3.1. Gender Bias in Schizotypy Studies

In all the student studies there was a sample bias towards higher numbers of female participants. This resulted from the recruitment of psychology undergraduate students, who at the point of testing were predominantly female. In terms of whether the gender bias has an effect on schizotypy scores, Miettunen and Jaaskelainen (2010) conducted a meta-analysis of studies looking into gender differences and schizotypy scores. They found that males scored significantly higher on the negative scales than the females, but for the positive scales there was only a borderline significant difference across gender on the perceptual aberration scale. However, this does not apply to the current studies as the three student samples were pooled and analysed for gender differences (36 males and 97 females) and there were no differences found for the total scores or any of the factors used in the covariate analysis in this thesis. This suggests that an imbalance in gender should not affect the schizotypy analysis.

5.3.2. Measure and Analysis for the Schizotypy Study

The fact that the studies in this thesis used the Schizotypal Personality Questionnaire and its factor scores as a covariate measure and did not divide the individuals into higher and lower scoring groups could be seen as an issue. Indeed, it is easier to analyse and interpret some of the higher order interactions once groups are used; however, the main reason for using a continuous measure was that it was deemed to be more representative of the schizophrenia spectrum viewed as a continuum. If this spectrum is continuous, than instead of categorising individuals as high and low scorers it is relevant to see if attention varies throughout the continuum, rather than only being evident in individuals with high numbers of the schizotypal traits. There is also a general issue of the use of self-report measures and the relation to honesty in responding to statements; however, schizotypy is generally measure this way as it is not necessarily an observable entity.

5.3.3. Sample size for the Schizophrenia Study

The sample size for the experiments involving individuals with a diagnosis of schizophrenia was fairly small. This was in part due to the high demands of the study, as it was conducted at the University over several sessions, although the payments for participation will have negated this for some individuals. There are two main problems with a small sample, the first is that the differences that are present between group do
not reach significance (Baer & Ahern, 1993), this in particular may represent a problem due to the larger variance in scores in the schizophrenia sample, which is a common finding due to the heterogeneous nature of the disorder (discussed below). There are a couple of notable instances where this may have occurred: in the classical version of the anti-saccade study where the difference in error rates between the schizophrenia and comparison group was close to significant, but failed to reach significance, based on previous research it is likely that with a larger sample this would have reached significance. The other instance is in the covert attention studies, where there were significant relationships between several of the WAIS-IV subset scores and the attention performance for the schizophrenia sample but not the comparison group. It seems likely that, with a larger comparison group, the attention measure would have also been related to performance for the non-clinical sample. However, it may be that better intellectual functioning may be more closely related to cognitive abilities in the schizophrenia sample than in the control sample, but a no-relationship conclusion for the control group cannot safely be drawn. Several other previous studies have used samples of similar size (e.g. Maruff et al., 1995), and in the present study the groups were found to differ on several measure across the three studies as detailed above in the discussion of main findings.

Another problem with a small sample is that outliers will have larger effects on the data as they represent a larger proportion when the sample is small. There are a couple of occasions where this has had an effect in the thesis (for example the relationship between criterion scores and the resistance factor in Chapter 3), but once graphs were examined this was easily identified. In general the findings for the schizophrenia sample that involved a relationship with the covariate measures should be interpreted with caution and although the findings here than involve these relationships may be of interest, they would need to be further investigated with larger samples before interpretations and conclusions based on these could be confidently stated.

5.3.4. Heterogeneity of Performance in the Schizophrenia Sample

In this thesis across the three experiments the schizophrenia group displayed a large variation in performance scores, with some individuals in this group performing as well as the comparison group, and others exhibiting much greater impairments. This is a consistent finding across several of the anti-saccade studies, where individuals
diagnosed with schizophrenia can show relatively preserved function or comparatively high error rates when compared to healthy control participants (Fukushima et al., 1988; Maruff et al., 1998). It may be that the attention deficits described in this thesis in relation to schizophrenia may be targets for treatments, especially as they were related to the WAIS scores in the case of the covert experiments, as this indicates relationships to more widespread impairments that have not be corrected by anti-psychotic medication. Supportive of this idea, some researchers have shown that looking into cognitive deficit profile can indicate how participants will respond to treatment, with individuals with general impairments responding poorly but those with specific cognitive deficits responding well to certain treatments (Gilbert et al., 2014).

5.3.5. Effects of Drug Dose and Qualitative issues of Anti-Psychotic Medication

In the current thesis, the individuals who formed the schizophrenia group were all medicated, with various medication profiles. All of these involved some kind of anti-psychotic medication, as well as several participants receiving other medication that included anti-depressant medication (see Appendix A for medication profiles of these participants). Although in the studies the dose equivalents were calculated, and these were used as covariates to investigate the quantitative effects of drug dose on performance in schizophrenia, it cannot be ruled out that group differences were related to the qualitative difference between those taking anti-psychotic medication and those not (the control group). Even if these group differences are not solely due to the anti-psychotic medication, it may be contributing to the group differences, and until some of these attention tasks are used as outcome measures in drug trials it is hard to decipher whether performance is enhanced or worsened by medication. However, current research seems to indicate that some antipsychotics at least improve performance in individuals diagnosed with schizophrenia (e.g. Burke & Reverley, 2002).

5.3.6. Lack of cueing effect in the COVAT study compared with utilization of the cue information in the anti-cue study.

In Chapter two where both a student sample and the schizophrenia group and comparison participants were given the version of the COVAT (with 70% validity), no significant main effect of cue was found. This was demonstrated across the signal trials, where no difference between valid and invalid cues were found, and for the cue
weighting measure which significantly differed from optimal, suggesting that the participants were not using the cue information effectively. This is against the findings across many previous studies where the measure was response time and the target was present on 100% of trials (Larrison et al., 2000; Maruff et al., 1995; Posner et al., 1988; Strauss et al., 1992; Strauss et al., 1991), as well as studies where there was a target presence judgement involved (Eckstein et al., 2002; S. S. Shimozaki et al., 2003; S. S. Shimozaki et al., 2012). All these studies demonstrated a cueing effect, with better performance and faster response to the more common valid cues over the invalid cues. One explanation for this lack of cueing effect may be that individuals in the current thesis’ studies were not processing the cue validity information provided in the instructions and thus not utilizing the cue in the task. However, Peterson and Gibson (2011) have shown that participants are able to implicitly learn the cue validity information; participants in their study were not given cue validity information, and also reported being unaware of the cue being predictive, yet they still demonstrated a cue validity effect, with faster responses for the valid over the invalid cue trials. The cues used in the Peterson and Gibson study were central arrows, so it could be that the participants were able to learn that type of cue more easily. Also in the study in this thesis it would be expected that participants would reflexively orient towards the cue, even without the cue information, thus affecting their performance and causing a main effect of cue. But as this was not happening, it appears that participants in these particular studies were actively ignoring the cues, rather than using them at all. Perhaps the cue information provided made participants believe that ignoring the cue was the best strategy to employ in response to the task as they did not feel 70% was predictive enough to aid their performance.

Another reason that participants may not have shown a cueing effect may be that they had not been presented with enough trials to ‘learn’ the cue validity, especially as in this thesis the participants had higher cognitive demands than just responding to an always present target. In the student sample there were only 180 trials, with 60 of these being neutral double cues, whereas there were 800 in the Peterson and Gibson study, and in some of the previous studies with the decision version of the COVAT participants have completed several thousand trials ((Eckstein et al., 2002; S. S. Shimozaki, 2010; S. S. Shimozaki et al., 2003). In the schizophrenia study there were 960 trials, which was substantially more than the student sample; the results of the same sample in the anti-cue task (from Chapter 3), where a cueing effect was found, may
support this idea. As effectively the anti-cue study was a continuation of sessions for this group from the cueing study, it may represent their ability to learn to use the cue after more practice on the tasks. The student sample in Chapter 3 also showed a significant effect of cue. In this study there were 360 trials, and also there was no double (neutral) cue, so it may be that the students, who are used to psychophysical studies, could learn to use the cue validity in these conditions in even less time than the participants from the community. This cue learning seems the most likely interpretation, as the two tasks only differed on the cue validity and for the schizophrenia sample were otherwise identical.

5.3.7. The difference in WAIS scores between the participants with a diagnosis of schizophrenia and their community comparison group

In this thesis the sample of individuals with a diagnosis of schizophrenia were shown to have a significantly lower than the standardized average estimated IQ, as well as scoring significantly lower than the comparison group on the four WAIS-IV subtests upon which they were tested (block design, arithmetic, information and coding). The block design represents the perceptual organization index, arithmetic the working memory index, information the verbal comprehension index, and coding the speed of processing measure, suggesting that the schizophrenia group were consistently poor across all these areas.

Deficits in each of these indexes have been found in individuals with schizophrenia. A meta-analysis conducted by Nuechterlein et al. (2004) supported the consistency of finding deficits across these measures for individuals diagnosed with schizophrenia, and suggested that they could be used as outcome measures for treatment due to the robustness of the deficits for this group. Although there is this prior evidence for individuals with schizophrenia having a deficit in scores on the WAIS subtests, the comparison group in this thesis also had significantly above average scores, which may have also affected the group differences.

The fact that the performance on the two covert attention tasks is related to WAIS scores within the schizophrenia group would suggest that problems with underlying attention shifts, or even the neural networks that underlie these shifts, cause poorer performance in tasks that involve higher level processes. In a future study it
would be interesting to get a larger sample of both individuals with schizophrenia and comparison subjects and match them more closely on WAIS scores, in order to examine the relationship between attention scores and IQ factors across these two groups. Furthermore, it would be interesting to see if practice on the covert cueing tasks, which appeared to improve performance in individuals with schizophrenia, also improved performance on IQ measure, thus suggesting it as a possible candidate for cognitive remediation therapy.

Concluding Comments

The studies in this thesis highlight several general deficits shown by individuals with a diagnosis of schizophrenia, relating to the ability to inhibit eye-movements, to exhibit the required response, and the time taken to respond to stimuli. Deficits were shown across both covert and overt attention. Conversely, these individuals showed preserved abilities across several strategic measures, including being relatively unaffected by the requirement to switch from reflexive to voluntarily controlled attention. This indicates that for individuals with schizophrenia there is some preserved functioning, particularly in relation to the control of attention and the ability to learn to use predictive information. This adds to the information on the preserved functions in schizophrenia. As for the consistent deficits shown, these could be used as measures for treatment outcomes, particularly based on their relationships with the WAIS scores, as well as possible areas for cognitive remediation therapies. There was also a consistent finding of asymmetry across the samples, independent of a diagnosis of schizophrenia and schizotypy scores supporting universal right hemisphere dominance for attention orienting on the covert cueing task.
### Appendix A: Medication Profiles for Participants in the Schizophrenia Group

<table>
<thead>
<tr>
<th>Participant Identification Number</th>
<th>Illness Duration (years)</th>
<th>Medication Type</th>
<th>Medication Name</th>
<th>Medication Dose</th>
<th>Dose Frequency</th>
<th>Chlorpromazine Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1645*</td>
<td>30</td>
<td>Antipsychotic (typical)</td>
<td>Haloperidol</td>
<td>150mg</td>
<td>Depot every 4 weeks</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Side effect Medication</td>
<td>Procyclidine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Antipsychotic (atypical)</td>
<td>Risperidone</td>
<td>4mg</td>
<td>Daily</td>
<td>400</td>
</tr>
<tr>
<td>2287*</td>
<td>11</td>
<td>Antidepressant</td>
<td>Fluoetine</td>
<td>40mg</td>
<td>Daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mood Stabiliser</td>
<td>Lithium</td>
<td>1g</td>
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*Denotes participants who did not participate in the anti-saccade part of the study.
Appendix B: Brief Psychiatric Rating Scale

**BRIEF PSYCHIATRIC RATING SCALE (BPRS)**

**Patient Name _____________________________**

Please enter the score for the term that best describes the patient’s condition.

*Today’s Date ____________*

0 = Not assessed, 1 = Not present, 2 = Very mild, 3 = Mild, 4 = Moderate, 5 = moderately severe, 6 = Severe, 7 = extremely severe

---

1. **SOMATIC CONCERN**
   Preoccupation with physical health, fear of physical illness, hypochondriasis

2. **ANXIETY**
   Worry, fear, over-concern for present or future, uneasiness.

3. **EMOTIONAL WITHDRAWAL**
   Lack of spontaneous interaction, isolation deficiency in relating to others.

4. **CONCEPTUAL DISORGANIZATION**
   Thought processes confused, disconnected, disorganized, disrupted.

5. **GUILT FEELINGS**
   Self-blame, shame, remorse for past behavior.

6. **TENSION**
   Physical and motor manifestations of nervousness, over-activation.

7. **MANNERISMS AND POSTURING**
   Peculiar, bizarre, unnatural motor behavior (not including tic).

8. **GRANDIOSITY**
   Exaggerated self-opinion, arrogance, conviction of unusual power or abilities.

9. **DEPRESSIVE MOOD**
   Sorrow, sadness, despondency, pessimism.

10. **HOSTILITY**
    Animosity, contempt, belligerence, disdain for others.

11. **SUSPICIOUSNESS**
    Mistrust, belief others harbor malicious or discriminatory intent.

12. **HALLUCINATORY BEHAVIOR**
    Perceptions without normal external stimulus correspondence.

13. **MOTOR RETARDATION**
    Slowed, weakened movements or speech, reduced body tone.

14. **UNCOOPERATIVENESS**
    Resistance, guardedness, rejection of authority.
<table>
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<tr>
<th></th>
<th><strong>UNUSUAL THOUGHT CONTENT</strong></th>
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<tr>
<td></td>
<td>Unusual, odd, strange, bizarre thought content.</td>
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<td>16.</td>
<td><strong>BLUNTED AFFECT</strong></td>
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<td>Reduced emotional tone, reduction in formal intensity of feelings, flatness.</td>
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<td>17.</td>
<td><strong>EXCITEMENT</strong></td>
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<td>Heightened emotional tone, agitation, increased reactivity.</td>
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<td></td>
</tr>
<tr>
<td>18.</td>
<td><strong>DISORIENTATION</strong></td>
</tr>
<tr>
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<td>Confusion or lack of proper association for person, place</td>
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</table>
Appendix C: Schizotypal Personality Questionnaire and Scoring

Breakdown

Please fill out the following questionnaire carefully and as accurately as possible, ticking Y(yes) for all the statements that you think apply to you and N(no) for all statements that you don’t think apply to you.

**MALE □ FEMALE □ (CHECK ONE)**

**Age ________**

1. Do you sometimes feel that things you see on the TV or read in the newspaper have a special meaning for you? Y □ N □
2. I sometimes avoid going to places where there will be many people because I will get anxious. Y □ N □
3. Have you had experiences with the supernatural? Y □ N □
4. Have you often mistaken objects or shadows for people, or noises for voices? Y □ N □
5. Other people see me as slightly eccentric (odd). Y □ N □
6. I have little interest in getting to know other people. Y □ N □
7. People sometimes find it hard to understand what I am saying. Y □ N □
8. People sometimes find me aloof and distant. Y □ N □
9. I am sure I am being talked about behind my back. Y □ N □
10. I am aware that people notice me when I go out for a meal or to see a film. Y □ N □
11. I get very nervous when I have to make polite conversation. Y □ N □
12. Do you believe in telepathy (mind-reading)? Y □ N □
13. Have you ever had the sense that some person or force is around you, even though you cannot see anyone? Y □ N □
14. People sometimes comment on my unusual mannerisms and habits. Y □ N □
15. I prefer to keep to myself. Y □ N □
16. I sometimes jump quickly from one topic to another when speaking. Y □ N □
17. I am poor at expressing my true feelings by the way I talk and look. Y □ N □
18. Do you often feel that other people have got it in for you? Y □ N □
19. Do some people drop hints about you or say things with a double meaning? Y □ N □
20. Do you ever get nervous when someone is walking behind you? Y□ N□

21. Are you sometimes sure that other people can tell what you are thinking? Y□ N□
22. When you look at a person, or yourself in a mirror, have you ever seen the face change right before your eyes? Y□ N□
23. Sometimes other people think that I am a little strange. Y□ N□
24. I am mostly quiet when with other people. Y□ N□
25. I sometimes forget what I am trying to say. Y□ N□
26. I rarely laugh and smile. Y□ N□
27. Do you sometimes get concerned that friends or co-workers are not really loyal or trustworthy? Y□ N□
28. Have you ever noticed a common event or object that seemed to be a special sign for you? Y□ N□
29. I get anxious when meeting people for the first time. Y□ N□
30. Do you believe in clairvoyancy (psychic forces, fortune telling)? Y□ N□
31. I often hear a voice speaking my thoughts aloud. Y□ N□
32. Some people think that I am a very bizarre person. Y□ N□
33. I find it hard to be emotionally close to other people. Y□ N□
34. I often ramble on too much when speaking. Y□ N□
35. My "non-verbal" communication (smiling and nodding during a conversation) is poor. Y□ N□
36. I feel I have to be on my guard even with friends. Y□ N□
37. Do you sometimes see special meanings in advertisements, shop windows, or in the way things are arranged around you? Y□ N□
38. Do you often feel nervous when you are in a group of unfamiliar people? Y□ N□
39. Can other people feel your feelings when they are not there? Y□ N□
40. Have you ever seen things invisible to other people? Y□ N□
41. Do you feel that there is no-one you are really close to outside of your immediate family, or people you can confide in or talk to about personal problems? Y□ N□
42. Some people find me a bit vague and elusive during a conversation. Y□ N□
43. I am poor at returning social courtesies and gestures. Y□ N□
44. Do you often pick up hidden threats or put-downs from what people say or do? Y□ N□
45. When shopping do you get the feeling that other people are taking notice of you? Y□ N□
46. I feel very uncomfortable in social situations involving unfamiliar people. Y N
47. Have you had experiences with astrology, seeing the future, UFOs, ESP or a sixth sense? Y N
48. Do everyday things seem unusually large or small? Y N
49. Writing letters to friends is more trouble than it is worth. Y N
50. I sometimes use words in unusual ways. Y N
51. I tend to avoid eye contact when conversing with others. Y N
52. Have you found that it is best not to let other people know too much about you? Y N
53. When you see people talking to each other, do you often wonder if they are talking about you? Y N
54. I would feel very anxious if I had to give a speech in front of a large group of people. Y N
55. Have you ever felt that you are communicating with another person telepathically (by mind-reading)? Y N
56. Does your sense of smell sometimes become unusually strong? Y N
57. I tend to keep in the background on social occasions. Y N
58. Do you tend to wander off the topic when having a conversation. Y N
59. I often feel that others have it in for me. Y N
60. Do you sometimes feel that other people are watching you? Y N
61. Do you ever suddenly feel distracted by distant sounds that you are not normally aware of? Y N
62. I attach little importance to having close friends. Y N
63. Do you sometimes feel that people are talking about you? Y N
64. Are your thoughts sometimes so strong that you can almost hear them? Y N
65. Do you often have to keep an eye out to stop people from taking advantage of you? Y N
66. Do you feel that you are unable to get "close" to people? Y N
67. I am an odd, unusual person. Y N
68. I do not have an expressive and lively way of speaking. Y N
69. I find it hard to communicate clearly what I want to say to people. Y N
70. I have some eccentric (odd) habits. Y N
71. I feel very uneasy talking to people I do not know well. Y N
72. People occasionally comment that my conversation is confusing. Y N
73. I tend to keep my feelings to myself. Y[N]  N[ ]
74. People sometimes stare at me because of my odd appearance. Y[ ]  N[ ]

Thank you for completing the questionnaire.
Now please check through and see if you have responded to all the questions and statements.
SCORING FOR SPQ

   Each "Yes" response on the SPQ scores one point. Total scores can therefore range from 0 to 74. Sub-scale scores can be calculated by summatting the following items:

   *Ideas of reference* 1 10 19 28 37 45 53 60 63

   *Excessive social anxiety* 2 11 20 29 38 46 54 71

   *Odd beliefs or magical thinking* 3 12 21 30 39 47 55

   *Unusual perceptual experiences* 4 13 22 31 40 48 56 61 64

   *Odd or eccentric behavior* 5 14 23 32 67 70 74

   *No close friends* 6 15 24 33 41 49 57 62 66

   *Odd speech* 7 16 25 34 42 50 58 69 72

   *Constricted affect* 8 17 26 35 43 51 68 73

   *Suspiciousness* 9 18 27 36 44 52 59 65

   Scores to measures three factors of schizotypy (Cognitive-Perceptual, Interpersonal, and Disorganized) can be derived by simple summation of the sub-scale raw scores for the relevant factors (see Factor Structure below for a breakdown).

Factor 1: Ideas of Reference  
(Cognitive-Perceptual) Odd beliefs / Magical Thinking  
Unusual Perceptual Experiences  
Paranoid Ideation

Factor 2: Social Anxiety  
(Interpersonal) No Close Friends  
Constricted Affect  
Paranoid Ideation

Factor 3: Odd Behavior  
(Disorganized) Odd Speech
References


Cella, M., Reeder, C., & Wykes, T. (2014). It is all in the factors: Effects of cognitive remediation on symptom dimensions. *Schizophrenia Research, 156*(1), 60-62. doi: [http://dx.doi.org/10.1016/j.schres.2014.03.032](http://dx.doi.org/10.1016/j.schres.2014.03.032)


older patients with right hemispheric stroke. Neurology, 71(18), 1439-1444. doi: 10.1212/01.wnl.0000327888.48230.d2


