Cognitive processes and emotion cue processing in introvertive anhedonia

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Abstract

Executive cognitive processes and emotion cue processing was explored in introvertive anhedonia, the O-LIFE’s negative schizotypal trait dimension, with the aim of identifying endophenotypes. The experimental work of the thesis was conducted in three distinct parts. The first two used reaction time tasks of selective attention to examine 1) the possibility of a general abnormality in executive cognitive functioning, and 2) the possibility of an emotion cue processing abnormality. Results from these two parts informed the development of the final experiment that used procedures adapted from animal associative learning to examine the interaction between executive cognitive processes and the processing of positive and negative emotional cues in 1) the learning of differentially reinforced biconditional discrimination and 2) the sensitivity to changes in the emotional valence of outcomes.

Two experiments, presented in Chapter 2, established that introvertive anhedonia was associated with an executive functioning deficit that could be characterised as a deficiency in processing context. Chapter 3 presented a further three experiments indicating that introvertive anhedonia had blunted processing of negative and positive emotional cues, but under certain specific conditions a bias to the processing of negative stimuli. The final experiment, presented in Chapter 4, found that introvertive anhedonia was behaviourally insensitive to outcome valence changes of stimulus-outcome associations.

The blunted processing of valenced stimuli seems to have influenced executive cognitive processes involved in both detecting the changes in outcome valence of associations and in forming new associations. An inability in introvertive anhedonia to adjust behaviour to changes in outcome valence might lead to perseveration, inappropriate responding and, in some situations, an over-exposure to aversive stimuli.

The executive cognitive deficits observed in section two, and the emotion cue processing deficits observed in section three might therefore result form failures in common mechanisms.
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Chapter 1:

General Introduction
1.1: Introduction

Diagnostic and Statistical Manual (DSM-IV: APA, 1994) diagnosis of schizophrenia can be made by the co-occurrence, for more than one month, of two or more of the following symptoms: hallucinations, delusions, disorganised speech, disorganised or catatonic behaviour and negative symptoms (e.g. flattening of emotions, apathy, social withdrawal). This criterion must also coincide with reduced social or personal occupational functioning for at least six months. The symptoms listed above can be grouped into positive and negative symptoms categories. According to Crow (1980), positive symptoms are abnormal by their presence, and include florid psychotic symptoms such as hallucinations and delusions, while negative symptoms are abnormal by their absence, which include flattening of affect, poverty of action and poverty of speech.

The aetiology of schizophrenia is complex and not completely understood. The biological and psychological underpinnings of positive and negative symptom clusters are somewhat paradoxical with models tending only to explain one set of symptoms. Considerable research efforts have gone into understanding positive symptoms, presumably due to their salience during psychotic episodes. This has culminated in the development of effective atypical antipsychotics in treating psychotic symptomatology. However, psychopharmacological treatments (Erhart, Marder Carpenter, 2006; Rosenheck et al., 1999) and cognitive behavioral therapies (Jones, Cormac, da Mota Neto, & Campbell, 2009) are largely ineffective in ameliorating negative symptoms therefore leaving a large proportion of schizophrenia symptoms untreated. Negative symptoms are a significant component of schizophrenia and, in contrast to positive symptoms, are associated with lower premorbid functioning, including occupational skill and IQ, poorer long-term outcome and in most cases a progressive course leading to permanent disability (Fenton & McGlashan, 1991). A recent consensus conference convened by the National Institute of Mental Health (NIMH: 2005, cited in Alphs, 2006) officially recognised the need for greater research into negative symptoms by stating that persistent and clinically significant negative symptoms are currently an unmet therapeutic need in a large proportion of schizophrenia cases.

The ultimate objective of the current research is to develop a greater understanding of the cognitive processes that might be specifically associated with the negative symptoms of schizophrenia. An increased understanding of cognitive processes in the negative
symptoms might contribute to theoretical models of schizophrenia that attempt to explain
the full range of symptoms. However, confounding variables typically associated with
schizophrenia research, such as medication, age of illness onset and illness duration are
likely to have significant impact on many cognitive processes. This investigation will
circumvent such confounds by examining the cognitions associated with schizotypal
personality traits that reflect the symptoms of schizophrenia in sub-clinical populations. It
will specifically address the objective by identifying and examining cognitive
endophenotypes that are associated with negative schizotypal. Endophenotypes are
features not visible to ‘the naked eye’ that are intermediate to the phenotype (i.e. expressed
genes that result in observable characteristics) and genotype (i.e. an organisms inherited
genes) for schizophrenia (e.g. Gottesman & Gould, 2003). For example, a phenotype of
schizophrenia might be psychotic symptoms such as hallucinations. However, an
endophenotype of schizophrenia might be an underlying cognitive deficit, such as failures
in sensory gating that are involved in causing the expression of the phenotype.

This introduction will firstly outline in greater detail the importance and centrality of
negative symptoms to schizophrenia. It will then define the term ‘schizotypy’ and the
theoretical framework that justifies its use as a research tool in the study of schizophrenia.
The Oxford Liverpool Inventory of Feelings and Experiences (O-LIFE, Mason & Claridge,
2006) will then be introduced and its use as the psychometric measure of schizotypy in the
current investigation justified. The schizotypy scores of the participant sample recruited
for the study will then be presented and compared to a normative data set (Mason &
Claridge, 2006). The introduction will then define and explore possible cognitive
endophenotypes that might be associated with the negative symptoms of schizophrenia.
The following section further identifies emotion cue processing as one area of cognition
that might provide a fruitful avenue of investigation. The introduction finally presents two
broad objectives that will provide the aims and direction of the thesis.

A Focus on Negative Symptoms/Traits in Schizophrenia and Schizotypy

This section will discuss the negative symptoms of schizophrenia and further highlight
why they are worthy of detailed study. Negative symptoms occur in mental illnesses
generally but are particularly high in psychotic illnesses (Herbener & Harrow, 2001).
They occur in the early stages of schizophrenia (Montague, Tantam, Newby, Thomas &
Ring, 1989) and unlike positive symptoms that are typically episodic, negative symptoms
are stable and endure throughout the course of the illness (Ring, Tantam, Monatgue &
Morris, 1991). There is strong support for the construct validity of negative symptoms in
schizophrenia. Earnst and Kring’s (1997) review identified a highly correlated set of
‘negative’ symptoms including anhedonia, flat or blunted affect, poverty of speech
(alogia), avolition and asociality, which were factorially independent of positive and
disorganised symptom domains. However, rather than being a symptom dimension of
schizophrenia or the severe end of a schizophrenia illness, the occurrence of primary and
enduring negative symptoms, referred to also as deficit symptoms, may represent a
separate disease within a schizophrenia syndrome (e.g. Kirkpatrick, Buchanan, Ross, &
Carpenter, 2001) (see Figure 1).

Carpenter, Heinrichs, and Wagman (1988) first proposed the deficit syndrome concept (see
Figure 1) by suggesting that a distinction could be made between primary and secondary
negative symptoms. Carpenter et al. (1988) noted that primary negative symptoms do not
appear to be related to transient or episodic factors and are primary idiopathic features of
schizophrenia. In contrast, secondary negative symptoms are transient and related to
medication side effects or secondary effects of schizophrenia such as depressive
anhedonia, anxiety and paranoid social withdrawal. Carpenter et al. (1988) therefore
proposed that enduring trait-like primary negative symptoms, refereed to as ‘deficit
symptoms’, might reflect a specific disease or subtype within a schizophrenia syndrome
consisting of restricted affect, diminished emotional range, poverty of speech, curbing of
interests, diminished sense of purpose, and diminished social drive (Carpenter et al., 1988; Kirkpatrick et al., 2001). Carpenter et al.’s (1988) approach focuses on discrete sign and symptom complexes with a deficit / non-deficit distinction based solely on the presence or absence of ‘deficit symptoms’. The occurrence of ‘deficit symptoms’ defines a group of patients with a schizophrenia disease, or deficit syndrome, that is different from patients with schizophrenia without deficit symptoms. Kirkpatrick et al (2001) further suggested that deficit and non-deficit schizophrenia differ not only in their signs and symptom complexes but also in illness course, biological correlates, treatment response and etiological factors (see also Buchanan & Carpenter, 1994). Carpenter et al.’s (1988) approach contrasts with other models of schizophrenia, such as Crow’s (1980, 1985) distinction between type I and type II schizophrenia that view schizophrenias subtypes as disease entities that are distinguished by multiple criteria.

As hypothesised by the deficit syndrome concept, Kirkpatrick and Buchanan (1990) found that deficit patients scored higher on measures of social and physical anhedonia but did not differ from non-deficit patients (i.e. patients with a diagnosis of schizophrenia who do not present with primary and enduring negative symptoms) on measures of positive symptoms including perceptual aberration and magical ideation. Furthermore, Blanchard, Horan and Collins (2005), using taxometric procedures, found a discrete class of individuals (or taxon) diagnosed with schizophrenia with elevated negative symptoms. Members of the taxon did not differ from non-members in levels of positive symptoms suggesting that negative symptoms were not merely a secondary feature of elevated positive symptoms. Deficit patients also report less trait positive affect (Horan & Blanchard, 2003), demonstrate poorer current social functioning (Blanchard et al., 2005; Horan & Blanchard, 2003), poorer current premorbid adjustment (e.g. Buchanan, Kirkpatrick, Heinrichs, & Carpenter, 1990; Fenton and McGlashan 1994; Horan & Blanchard, 2003) and greater neuropsychological impairment (Bryson, Whelahan, Bell, 2001; Buchanan et al., 1990; Horan & Blanchard, 2003; Ross et al., 1996). Negative symptoms generally are also related to poorer long-term prognosis. In a long term study of negative and positive symptoms, Fenton and McGlashan (1991) found that although the severity of positive symptoms predicted future hospitalisation they were relatively unrelated to a patient’s ability to function in employment or engage in social activities. In contrast, negative symptoms were associated with lower premorbid functioning, including occupational skill and IQ, poorer long-term outcome.
Anhedonia is a prominent feature of negative symptoms and a feature of Meehl’s (1962) model of the pathogenesis of schizophrenia. He described anhedonia as “one of the most consistent and dramatic behavioural signs of the disease” (Meehl, 1962, p829). Furthermore, Blanchard, Gangestad, Brown and Horan (2000) suggested that social anhedonia might be an indicator of schizotypy. Consistent with the findings of a negative symptom taxon in schizophrenia (Blanchard et al., 2005), Blanchard et al. (2000) found that social anhedonia constituted a taxon among an undergraduate population. The taxon had a base rate estimate that was approximate to that conjectured by Meehl for schizotypy (i.e. 10% of the general population; see also Horan, Blanchard, Gangestad, & Kwapis, 2004 for replication). Although the debate continues regarding whether the latent structure of schizotypy is taxonic (e.g. Beauchaine, Lenzenweger & Waller, 2008) or continuous (e.g. Rawlings, Williams, Haslam & Claridge, 2008), high scores on measures of social anhedonia have been linked to an increased probability of receiving a future diagnosis of a schizophrenia spectrum disorder. Kwapis (1998), for example, reported no difference in the percentage of a schizophrenia spectrum diagnosis between people scoring high on a measure of social anhedonia and a control group at initial assessment. However, at a ten year follow up, 24% of the social anhedonia group had a diagnosis of a schizophrenia spectrum personality disorder compared to 1% of a control group. In contrast, a related study observed that high scores on measures of positive traits/symptoms (i.e. perceptual aberration and magical ideation scales) had heightened rates of non-schizophrenia psychotic like illnesses at ten year follow up (Chapman, Chapman, Kwapis, Eckblad & Zinser, 1994). This suggests that while increased positive traits increase the probability of psychosis, only negative schizotypy traits increase the probability of schizophrenia.

The negative symptoms of schizophrenia are clearly a central component of schizophrenia. Furthermore, the occurrence of primary negative symptoms is thought to reflect a disease subtype within a schizophrenia syndrome. Such a ‘deficit syndrome’ might be a category, or taxon, rather an extreme presentation of negative symptoms. Furthermore, patients who present with such symptoms have a poor current and long term prognosis including lower social functioning and greater neuropsychological impairment. However, despite this evidence indicting the central role of negative symptoms in schizophrenia they are, currently, largely untreatable. Cognitive behavioural therapies are largely ineffective (Jones, Cormac, da Mota Neto & Campbell, 2009) and despite the effectiveness of atypical antipsychotics in treating positive symptoms, such as hallucinations and delusions, they do not have a comparable effect on negative symptoms (Rosenheck et al., 1999) or cognition (Keefe et al., 2007), which is also severely impaired in patients with schizophrenia (Braff
et al., 1991; Saykin et al., 1991). A large proportion of schizophrenia symptoms are therefore left untreated. A greater understanding of negative symptoms might therefore stimulate new theory and research that might provide a means of developing new therapies effective for negative symptoms.

As briefly outlined above, the current investigation sought to explore and possibly identify cognitive endophenotypes that are associated with the negative symptoms of schizophrenia. As the negative symptoms of schizophrenia are characteristic of reduced emotionality, then the cognition associated with emotional cue processing might be a fruitful avenue of exploration. Furthermore, an understanding of the cognitive processes that underpin a possible emotion cue processing deficit might provide further clues as to the cognitive processes or mechanisms that underpin or maintain negative symptoms.

The current research aimed to account for confounding variables that are typically associated with schizophrenia research such as medication, age of illness onset and illness duration. The exploration of cognition makes these confounds (especially the effects of medication) specifically relevant to the current investigation. To account for these confounds and for other reasons outlined at the end of the next section, the current research chose a strategy that examined schizotypal traits in non-clinical populations. The following section will therefore define ‘schizotypy’ and the theoretical framework that justifies its use in the current investigations experiments.

1.2: Schizotypy: Theoretical Issues

Schizotypy Defined

The term schizotypy was first used by Rado (1953), in the form ‘schizotype’ as an abbreviation of schizophrenic genotype, to describe relatives of patients diagnosed with schizophrenia that had peculiar behaviour. Kety, Rosenthal, Wender, and Schulsinge (1968) also noted qualitative similarities in the features that characterise the diagnosis of schizophrenia, ‘borderline’ schizophrenia and ‘inadequate personality’. Such observations provide validity for a schizophrenia spectrum of disorders. Indeed, the inclusion of ‘Schizotypal Personality Disorder’ (SPD) as a borderline state in DSM-III (APA, 1980) indicated a formal conceptual shift away from considering schizophrenia as a discrete disorder. SPD is characterised by similar symptom clusters to schizophrenia that are
“...not severe enough to meet criteria for schizophrenia” (DSM-III, p.312). Psychotic episodes may be triggered by extreme stress. However, these episodes will be transient and not as severe as those found in schizophrenia. Schizophrenia may therefore represent the severe end of a spectrum of disorders with SPD as a borderline state and schizotypy as an ‘inadequate personality’ in sub-clinical populations.

Such observations indicate that the aetiology of schizophrenia has an inherited component. Indeed, the expression of phenotypic schizophrenia is thought to be polygenically determined (Gottesman and Shield, 1967), meaning that large numbers of genes contribute additively to the overall liability for developing a disorder. However, environmental stress is also thought to interact with such an inherited diathesis in a polygenic multifactorial threshold model (Gottesman, 1991). Such a model proposes that phenotypic schizophrenia would occur, for example, when inherited liability and environmental stress additively exceed a given threshold. Numerous genetic epidemiological studies indicate the inheritability of schizophrenia (Gottesman, 1991). Such studies support a gene-environment interaction as the concordance for schizophrenia in monozygotic twins is typically around 50% and heritability estimates are less than 100%.

One influential conceptual model for the pathogenesis of schizophrenia, the schizotaxia-schizotypy model (Meehl’s 1962, 1989), suggests that schizotaxia, a hypothetical neuropsychological deficit termed ‘hypokrisia’ is inherited; schizotaxia then interacts with a social learning history that results in a personality organisation referred to, following Rado (1953), as schizotypy. The model proposes that all schizotaxic individuals would become schizotypal but only a small number of these schizotypic personalities, under the influence of other genetically determined personality traits (i.e. polygenic potentiators such as anxiety, hedonic potential, social introversion), de-compensate into clinical schizophrenia. According to Meehl, therefore, schizotypy is a personality organisation reflecting a latent liability for schizophrenia and can manifest itself behaviourally and psychologically in various degrees of clinical compensation.

**Fully vs. Quasi Dimensional View of Schizotypy**

Claridge and Beech (1995) made a distinction between ‘quasi-dimensional’ and ‘fully-dimensional’ models of schizotypy. These reflect the dimensionality of schizotypal traits within clinical psychology and personality psychology respectively. Schizotypy within the
clinical perspective represents the *forme fruste* of schizophrenia disease. “The symptoms of illness can manifest themselves with varying severity, dependent upon the degree of expression of the relevant underlying cause. This in turn will be influenced by the presence or absence, or strength or weakness, of other modifying factors in the aetiology” (Claridge, 1997 p.10). A quasi-dimensional model is consistent with Meehl’s (1962) schizotaxia-schizotypy model where schizotypy is partially expressed schizotaxia. The development of schizophrenia or a borderline condition such as schizotypal personality disorder reflects the degree of compensation. Theorising a “mixed model” of genetic influence Meehl proposed that a single major locus, “the schizogene”, interacts with an additive polygenic and the environment. A person is therefore either schizotaxic or not, predisposed to schizophrenia or not, possesses the ‘schizogene’ or not. Theoretically, a continuum of psychosis is only present, within a quasi-dimensional model of schizotypy, as a representation of the degrees of compensation in an underlying disease process. The aetiological investigation therefore focuses on the nature and cause of an inherited neuropsychological deficit.

A fully-dimensional model incorporates the quasi-dimensional component but views psychotic characteristics as individual difference traits, such as anxiety, that are both a source of healthy variation and a predisposition to a disorder (i.e. psychosis-proneness). This view is grounded in the Eysenckian school of personality psychology where dimensionality “refers to a continua that describe smoothly varying individual difference in healthy functioning that have no necessary reference point in abnormality (except in a purely statistical sense)” (Claridge, 1997 p.11). It takes little account of any distinctions or discontinuities that exist between symptoms and traits. Such an approach is more consistent with a multifactorial polygenic threshold model (Gottesman, 1991), which although predicting a qualitative discontinuity at the level of the phenotype, liability is predicted to be continuously distributed. Even when the necessary genotype is present, it may not be expressed as clinical disease. This model suggests that a number of major schizophrenia loci (oligogenic) interact with other polygenic traits and environment in the determination of expressed schizophrenia. The aetiological investigation for a fully-dimensional model, therefore, contrasts radically with that of a quasi-dimensional model. It seeks to incorporate information from numerous individual differences, such as personality, cognitive, emotional, social and genetic that might contribute to a schizophrenia diathesis and environment and their interaction rather than focussing on only one possible pathological cause.
Given that those with a liability to schizophrenia may never display an overt psychosis, research has made efforts to discover valid objective endophenotypic indicators of schizotypy that function reliably across degrees of clinical compensation and that are capable of detecting liability even in unexpressed (i.e. non symptomatic) cases. Prior to reaching a liability threshold such ‘endophenotypic information’, including cognitive measures such as attention and information processing, psychometric measures such as sub-clinical personality traits and biological measures such as levels and functioning of neurotransmitters and receptors, form the multiple sources of liability information that provide information into the possible causes for clinical decompensation into schizophrenia. The approach of identifying valid objective endophenotypic indicators of schizotypy was the central strategy of the current investigation. It sought to identify cognitive and emotional cue processing endophenotypes, specifically in ‘negative schizotypy’, one of the four trait dimensions of schizotypy that are discussed in further detail below.

**Multidimensionality of Schizotypal Traits**

Rather than reflecting a single dimension, schizotypy appears to be heterogeneous consisting of multi-dimensions. Attempts to establish the factor structure of schizotypy involve factor analyses of traits that are similar to the symptom characteristics of schizophrenia. The number of factors emerging from such analyses varies between two and four (Mason, Claridge & Williams, 1997; Vollema & van den Bosch, 1995) depending on the item content used. However, there is now some consensus that schizotypy consists of three factors; ‘positive schizotypy’, ‘negative schizotypy’ and ‘cognitive disorganisation’ (Vollema & Hoijtinkm, 2000)

One influential study factor-analysed responses from a large battery of 15 trait and symptom scales in the development of the Combined Schizotypal Traits Questionnaire (CSTQ; Bentall, Claridge Slade, 1989). It revealed three factors: unusual experiences, cognitive disorganisation and introvertive anhedonia. An additional fourth factor was also identified which was labelled ‘asocial behaviour’. This factor loaded on three scales not included in other factor structure studies, that is, Eysenck P-scale (Eysenck & Eysenck, 1979), the Hypomania scale (Eckblad & Chapman, 1986), and the Borderline Personality scale (Claridge & Broks, 1984) and was thought to reflect a broader concept of ‘psychosis proneness’ (Claridge, 1997) or unitary (Einheitpsychose) theory of psychosis (e.g. Kendell,
An extension and replication study that factor analysed the same 15 scales with a large sample of over a 1000 subjects produced similar results (Claridge, et al., 1996). The CSTQ was therefore condensed, due to its length (420 items) and repetitiveness, using exploratory and confirmatory factor analyses in the development of the Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) (Mason, Claridge & Jackson 1995; see also Mason & Claridge, 2006 for further description and extended norms).

The O-LIFE was developed within the sphere of a fully-dimensional model. Its construction deliberately focussed on traits, rather than symptoms, and excluded stronger clinically worded items. This makes the O-LIFE particularly useful in studying a non-clinical population and was the main reason for its selection as the schizotypy measures in the current thesis. The questionnaire measures the four factors identified by the CSTQ. The ‘Unusual Experiences’ scale contains items describing perceptual aberrations, magical thinking and hallucinations. It measures a trait often referred to as ‘positive schizotypy’ and is related to the positive symptoms of psychosis. The ‘Cognitive Disorganisation’ scale measures aspects of poor attention and concentration as well as poor decision making and social anxiety. It reflects thought disorder and other disorganised aspects of psychosis. The ‘Introvertive Anhedonia’ scale measure a lack of enjoyment from social and physical sources of pleasure as well as avoidance of intimacy and is the schizotypy trait dimension of interest in the current investigation. It measures a trait often referred to as ‘negative schizotypy’ and reflects a weakened form of negative symptoms; the importance of which to the investigation of schizophrenia will be highlighted in detail in the next section. The ‘Impulsive Nonconformity’ scale contains items describing impulsive, anti social and eccentric forms of behaviour, often suggesting a lack of self control and, as mentioned above, was intended to capture a broader concept of psychosis-proneness, or unitary psychosis (e.g. Kendall, 1991), reflecting the possible separability of other psychotic like characteristics from strictly schizotypal features. The O-LIFE is established to have high internal consistency: Unusual Experiences =0.89; Cognitive Disorganisation =0.87; Introvertive Anhedonia =0.82; and Impulsive Nonconformity =0.77 (Mason, Claridge & Jackson, 1995), which has since been confirmed by Rawlings and Freeman, (1997: 0.77, 0.81, 0.85 and 0.72 respectively). The O-LIFE also has similarly high test-retest reliability being greater than 0.70 (Burch, Steel & Hemsley, 1998).

Consistent with a schizophrenia spectrum of disorders, schizotypal dimensions, as identified by the O-LIFE, mirror the symptom dimensions of schizophrenia (Vollema and van den Bosch, 1995). Three symptom clusters are consistently found in schizophrenia...
(e.g. Arndt, Allinger & Andreasen, 1991; Liddle, 1987), which Liddle (1987) labelled “Reality Distortions”; “Disorganisation”; and “Psychomotor Poverty”, reflecting the O-LIFE dimensions “Unusual Experiences”; “Cognitive Disorganisation” and “Introvertive Anhedonia” respectively.

### 1.3: Collection of O-LIFE data

During the course of the current investigation, O-LIFE data was collected from 304 participants. These data are presented in the following tables (Tables 1-5) that also present, in bold print, normative data of 1926 participants for comparison (Mason & Claridge, 2006). The purpose of this section is to examine whether there are any notable differences between the demographics of the O-LIFE data collected for the current thesis and the demographics of the normative data. For reasons discussed in the next section, ‘a focus on negative symptoms’, the introvertive anhedonia O-LIFE dimension is of specific interest to the current investigation and this analysis will make detailed reference to it.

Table 1 below presents the proportions of collected O-LIFE data distributed across gender and age groups, which also includes the distribution of normative data presented in bold print. An examination of the totals row at the bottom of the table shows that the sample of the current investigation had a clear gender bias. However, chi square analyses confirmed that such a bias was comparable to that observed in the normative sample with around 75% of both samples being female. An examination of the final column, which presents the percentage of the samples in each of the age groups, shows that the current sample had an age bias with around 70% being younger than 22 years. This departs from the normative sample which has a more even spread of participants across the 6 different age groups. Twenty one percent of the normative sample was younger than 22 years, a further 21% were between 22 and 30 years and around 15% of the sample were from each of the other age groups.

A closer examination of the gender bias of the current sample in each of the 6 age groups also reveals departures from the bias observed in the normative data. For those younger than 22 years, chi square analyses indicate that there was a significantly greater female to male ratio in the current sample than the normative sample. This pattern was also observed, and confirmed with chi square analyses, in the 22-30 years age category.
However, similar departures from the normative sample were not observed in the any other age categories.

Table 1
The percentage of males and females in 6 age groups, the significance values of 2x2 chi square analyses of gender percentages for each age group (comparing percentages from the current sample with percentages from the normative sample) and the percentage of the total sample in each of the 6 age groups. (n=304; normative data presented in bold, n=1926, Mason & Claridge, 2006)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Gender</th>
<th>Chi square</th>
<th>% of total sample in each age group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td></td>
</tr>
<tr>
<td>&lt;22</td>
<td>77</td>
<td>23</td>
<td>p&lt;.001</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>22-30</td>
<td>74</td>
<td>26</td>
<td>p&lt;.05</td>
</tr>
<tr>
<td></td>
<td>62</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>31-40</td>
<td>77</td>
<td>23</td>
<td>p&gt;.05</td>
</tr>
<tr>
<td></td>
<td>81</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>41-50</td>
<td>80</td>
<td>20</td>
<td>p&gt;.05</td>
</tr>
<tr>
<td></td>
<td>78</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>51-60</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>&gt;60</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>82</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>77</td>
<td>23</td>
<td>p&gt;.05</td>
</tr>
<tr>
<td></td>
<td>73</td>
<td>27</td>
<td></td>
</tr>
</tbody>
</table>

In sum, the current sample had a female gender bias that was comparable to the normative data. However, compared to the normative data, the female gender bias of the current sample was significantly larger in the two younger age groups.

Table 2 displays the normed estimated means of males and females for the four O-LIFE subscales. They indicate that while males score higher for unusual experiences and cognitive disorganisation they score lower for introvertive anhedonia and impulsive nonconformity. The table also includes the F values of the ANCOVA’s that examined
these gender differences while controlling for age. They indicate that the gender differences were significant for all subscales except unusual experiences.

Table 2
Normative estimated means and effect size for males (n=521) and females (n=1405) collected by Mason and Claridge (2006)

<table>
<thead>
<tr>
<th></th>
<th>Estimated means</th>
<th>F</th>
<th>Effect size (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td></td>
</tr>
<tr>
<td>UnEx</td>
<td>8.17</td>
<td>8.84</td>
<td>0.17ns</td>
</tr>
<tr>
<td>CogDis</td>
<td>10.14</td>
<td>10.81</td>
<td>5.08*</td>
</tr>
<tr>
<td>IntAn</td>
<td>7.07</td>
<td>6.11</td>
<td>17.56**</td>
</tr>
<tr>
<td>ImpNon</td>
<td>8.55</td>
<td>7.27</td>
<td>43.7**</td>
</tr>
</tbody>
</table>

* p<0.05, **p<0.01

The current sample had a large age bias with around 70% being under 22 years. ANCOVA’s could therefore not be conducted, as the age variable was skewed and did not correlate with any of the O-LIFE subscale scores. Gender differences were however analysed without controlling for age using t-tests (see Table 3).

Table 3
O-LIFE subscale means for males (n=71) and females (n=233) and t test values and effect size of the difference

<table>
<thead>
<tr>
<th></th>
<th>Means</th>
<th>t</th>
<th>Effect size (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td></td>
</tr>
<tr>
<td>UnEx</td>
<td>8.92</td>
<td>9.38</td>
<td>0.514ns</td>
</tr>
<tr>
<td>CogDis</td>
<td>13.09</td>
<td>13.15</td>
<td>0.087ns</td>
</tr>
<tr>
<td>IntAn</td>
<td>4.60</td>
<td>6.06</td>
<td>2.730**</td>
</tr>
<tr>
<td>ImpNon</td>
<td>8.82</td>
<td>9.93</td>
<td>2.042*</td>
</tr>
</tbody>
</table>

* p<0.05, **p<0.01
Analyses of data in table 3 indicate that males and females of the current sample did not have significantly different unusual experiences scores, an observation that is consistent with the normative sample. However, the analyses did reveal several departures from the normative data. Firstly, males and females of the current sample did not have significantly different cognitive disorganisation scores as they had in the normative sample. Also, males of the current sample had significantly higher rather then lower introvertive anhedonia and impulsive non-conformity scores than females.

In sum, the male gender bias in the normative data for cognitive disorganisation was not observed in the current sample. Furthermore, the female bias in the normative sample for introvertive anhedonia and impulsive non-conformity was reversed in the current sample.

Table 4 below presents the intercorrelations of the O-LIFE subscales for the current sample and the normative data in bold. The direction and strength of these correlations in the current sample are comparable to those in the normed data set for all O-LIFE subscales except for one notable exception. The current sample has a weak to moderate significant positive correlation between introvertive anhedonia and unusual experiences subscale.

### Table 4
Partial correlations between O-Life subscales (controlling for sex and age) n=304 (Mason and Claridge 2006 normative data in bold n=508)

<table>
<thead>
<tr>
<th></th>
<th>UnEx</th>
<th>CogDis</th>
<th>IntAn</th>
</tr>
</thead>
<tbody>
<tr>
<td>CogDis</td>
<td>0.51**</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td></td>
<td>0.48**</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td>IntAn</td>
<td>0.27**</td>
<td>0.32**</td>
<td>_</td>
</tr>
<tr>
<td></td>
<td>0.09**</td>
<td>0.32**</td>
<td>_</td>
</tr>
<tr>
<td>ImpNon</td>
<td>0.43**</td>
<td>0.29**</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>0.39**</td>
<td>0.28**</td>
<td>-0.07**</td>
</tr>
</tbody>
</table>

** p<.01

The weak but significant correlation between introvertive anhedonia and unusual experiences (Table 4) indicates that trait 'negative schizotypy' is co-occurring with trait 'positive schizotypy'. However, the correlation in the normative data set is very small suggesting that that the positive and negative trait dimensions are very weakly correlated in
larger samples. This observation must be highlighted as the current study examined experimental effects in introverted anhedonia with the aim of making trait effect associations. Positive and negative schizotypal traits are likely to have unique causes and consequences and therefore the inability to separate them is a confounding factor to the investigations of such trait effect associations.

The current study adopted analyses of extremes that prospectively selected high and low introverted anhedonia groups based the normed upper and lower introverted anhedonia quartile scores of 1926 participants for males and female of different age groups (Mason & Claridge, 2006). These normative data, presented in bold, are included in Table 5 below, which also presents these upper and lower quartile scores, the median and the 90th percentile of the current sample. Table 5 again shows a clear age bias in the current sample with a majority being younger than 30 years of age. However, an examination of males and females introverted anhedonia scores for the <22 years group indicates only small differences from the same scores of the normed data set. These differences become larger as the age of the sample increased and as the numbers of people in those older age groups of the current sample decreases. This suggests that when the sample size approaches that of the size of the normative sample then the distribution of introverted anhedonia scores becomes more comparable to that of the normative data set. Sampling from the upper and lower introverted anhedonia quartiles of the current sample would therefore produce high and low introverted anhedonia groups with comparable introverted anhedonia scores to those in the normative data set.

The current investigation collected O-LIFE data and then prospectively selected extreme scoring high and low introverted anhedonia groups based on age and gender upper and lower quartile scores of the normed introverted anhedonia distribution (Mason & Claridge 2006; see Table 5). Levels of introverted anhedonia differ between males and females. Furthermore, levels of introverted anhedonia increase as people become older. The current recruitment strategy would therefore always recruit people in the extremes of the introverted anhedonia distribution regardless of their age or gender.
Table 5
First quartile, median, third quartile and 90th percentile for male and females by age group (n=304) (Mason & Claridge 2006 normed data in bold, n=1926). Recruitment of high and low introvertive anhedonia groups in the current study was based on normed upper and lower quartile scores (presented in italics) of the normed introvertive anhedonia distribution. This strategy would recruit people in the extremes of the distribution regardless of their age or gender.

<table>
<thead>
<tr>
<th>Age group</th>
<th>N size</th>
<th>Unusual Experience</th>
<th>Cognitive Disorganisation</th>
<th>Introvertive Anhedonia</th>
<th>Impulsive Nonconformity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>&lt;22</td>
<td>169</td>
<td>50</td>
<td>3, 6, 13, 18</td>
<td>3.8, 9, 15.3, 18.9</td>
<td>9, 13, 17, 21</td>
</tr>
<tr>
<td>237</td>
<td>159</td>
<td></td>
<td>4, 9, 15, 19, 2</td>
<td>4, 9, 15, 19, 21</td>
<td>8, 13, 17, 21</td>
</tr>
<tr>
<td>22-30</td>
<td>39</td>
<td>14</td>
<td>3, 8, 15, 19</td>
<td>4.8, 8, 10, 13</td>
<td>9, 14, 16, 18</td>
</tr>
<tr>
<td>250</td>
<td>152</td>
<td></td>
<td>4, 9, 14, 20</td>
<td>4, 9, 14, 19</td>
<td>7, 12, 17, 19</td>
</tr>
<tr>
<td>31-40</td>
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<td>5</td>
<td>7, 11, 17.5, 22</td>
<td>5.7, 10.5, 11</td>
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<td>41-50</td>
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<td>4, 7, 10, 18.4</td>
<td>6, 10, 14, 19.1</td>
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A strategy that recruits participants from the extremes of the introvertive anhedonia distribution regardless of age and gender would, for example, categorise a 21 year old female participant as a high introvertive anhedonic if their introvertive anhedonia score were 7 or greater (see table 5). However a male participant of the same age would require an introvertive anhedonia score of 8 or greater to be categorised as a high introvertive anhedonic. Similarly, a 21 year old female would be categorised as a low introvertive anhedonic if their introvertive anhedonia score were 2 or less. However, a male participant of the same age would need an introvertive anhedonia score of 3 or less to be categorised as low introvertive anhedonia. In contrast to individuals in the <22 age group, a 35 year old female participant would need to have an introvertive anhedonia score of 8 or higher to be categorised as a high introvertive anhedonic while a male participant of the same age would require an introvertive anhedonia score of 9 or higher to be categorised as high introvertive anhedonic (see table 5).

Conclusions

Schizotypy is defined as a personality organisation that reflects a latent liability for schizophrenia and can manifest itself behaviourally and psychologically in various degrees of clinical compensation. It can be viewed within quasi-dimensional model, as a compensated form of schizophrenia, or within a fully-dimensional model, as a personality trait that can be both a source of healthy variation and a predisposition to a disorder. Researchers seek to the identify endophenotypes, or objective indictors, that form the liability information that can provide insight into the possible causes for clinical decompensation into schizophrenia.

Schizotypy has multiple trait dimensions that parallel the symptom clusters of schizophrenia. The O-LIFE was chosen to measure these schizotypy trait dimensions in the current investigation, as it is a reliable and valid measure that was specifically designed for use with sub-clinical populations. An examination of the O-LIFE subscales and demographic data of 305 participants recruited for the current investigation revealed some departures from the normative data set. The current sample had a young age bias, which also had a larger female to male ratio than normative data set.

However, an examination of the data for the O-LIFE’s measure of the negative schizotypal trait dimension (i.e. introvertive anhedonia), which is of particular interest to the current
investigation, revealed comparable scores with the normative data set in younger age groups where the sample size approached that of the normative data set. Sampling from these younger age groups would therefore produce groups with comparable distributions of introvertive anhedonia scores of those in the normative data set.

The strategy of this investigation was to explore cognitions associated with schizotypal traits in non-clinical populations rather than groups with a current diagnosis of schizophrenia. This was chosen for three main reasons. Firstly, this study was exploratory and wished to begin the investigation at a logical start point at the ‘normal’ sub-clinical end of a conjectured schizophrenia illness continuum. Secondly, negative schizotypal traits are an indicator of a future diagnosis of a schizophrenia spectrum disorder and could be an endophenotype of schizophrenia. The exploration of cognitions and emotion cue processing in schizotypy might therefore generate new theoretical directions regarding the contribution of negative schizotypal traits to schizophrenia. Thirdly, any examination of cognitive processes in schizophrenia is likely to be confounded by numerous variables including intended clinical effects and no intended side effects of medication, age of illness onset, illness duration and effects of institutionalisation.

The next section will outline the possible cognitive endophenotypes that might be associated with the negative symptoms of schizophrenia and negative schizotypal traits. The following section will then briefly review research that has explored emotionality in schizophrenia and schizotypal traits and highlight that emotion cue processing might be one aspect of cognition worthy of detailed study in negative schizotypy.

1.4: Cognitive deficits in Schizophrenia/Schizotypy: the search for endophenotypes

Overview of Hypothesised Cognitive Deficits in Schizophrenia and Definition of Key Terms

Patients with a diagnosis of schizophrenia display deficits on almost all cognitive or neurological tasks but specifically on tasks of executive functioning and learning. To reflect the involvement of the hypothesised brain circuitry Lencz, Raine, Benishay, Mills
and Bird (1995) referred to these deficits as ‘frontolimbic’ since executive and learning systems are believed to be subserved by the prefrontal lobes with connections to the limbic cortex. Lencz et al. (1995) further suggested that different cognitive deficits would be expected from breakdowns at different points in the circuit. However, the search continues for a core deficit in schizophrenia that provides a plausible link to the full range of symptoms that might also represent a phenotypic marker for the susceptibility of developing the disorder.

Previous hypothesised core deficits in schizophrenia have proposed a central executive dysfunction that results in the increased influence of unconscious processes (Frith, 1979, 1992). This was initially conceptualised as a defective filter that underpins an inability to focus attention, inhibit irrelevant stimuli and thereby control the content of consciousness (Frith, 1979) or ‘an awareness of automatic processes, which are usually carried out below the level of consciousness but are available to consciousness’ (Frith 1979, p233). This hypothesis rests on the presumption that the normal process of attending to a particular stimulus involves the active inhibition of competing stimuli and such a failure to inhibit causes, in schizophrenia, hallucinations, explanatory delusions, and formal thought disorder (Frith, 1979).

More recently, Frith (1992) proposed that an inability to construct and monitor metarepresentations (i.e. second order representations of conscious awareness) is the primary deficit underlying the positive and negative symptoms and signs of schizophrenia. Such a deficit impairs (1) an awareness of one’s own goals that in turn underpins an inability to generate spontaneous acts and leads to poverty of action, perseveration and inappropriate action; (2) impairs an awareness of intentions that underpins an inability to monitor willed intentions and leads to delusions, hallucinations and thought insertion; (3) impairs an awareness of the intentions of others that underpins an inability to monitor the beliefs and intentions of others and leads to delusions of reference, paranoid delusions, incoherence and third person hallucinations.

A currently favoured hypothesis proposes that a weakening of the ability to process context is a central cognitive deficit in schizophrenia (e.g. Cohen & Servan-Schreiber, 1992,) and that such a deficit is underpinned by executive dysfunction of the prefrontal cortex (Barch, et al., 2001; Miller & Cohen, 2001). Hemsley (2005) notes that a deficit in the processing of contextual information provides a plausible link to a range of symptoms including hallucinations, delusions and formal thought disorder. For example, conditional reasoning
deficits or ‘jump to conclusions’ style of reasoning is thought to underpin the experience of delusions (e.g. Garety & Freeman, 1999). That is, the knowledge stored in semantic memory influences reasoning judgments (Cummins, Lubart, Alksnis & Rist, 1991; Cummins, 1995) and errors in its use are thought to underpin conditional reasoning deficits (Sellen, Oaksford & Gray, 2005). Delusions are therefore thought to occur from an inability to use context information stored in semantic memory resulting in the early acceptance or rejection of invalid and valid logical constructs (i.e. if…then arguments) during conditional reasoning.

Hemsley (2005) further suggests that a deficit in context processing has an additional advantage in accounting for two crucial cognitive processes thought to be impaired in schizophrenia, namely working memory (e.g. Park & Holzman, 1992; Goldman-Rakic & Selemon, 1997) and inhibitory processing (e.g. Braff, Swerdlow & Geyer, 1999). For example, Cohen and Servan-Schreiber (1992) demonstrate how a disturbance in the internal representation of contextual information can provide a common explanation for deficits that participants with a diagnosis of schizophrenic display on tasks of language and attention that are traditionally thought to rely on working memory and inhibitory processing.

A further discussion of these deficits and how they might relate to the negative symptoms of schizophrenia cannot proceed until the terms “executive functioning” and “context processing” are clearly defined.

**Definition of key Terms**

The terms ‘executive functioning’ and ‘context processing’ are used generally to mean the application of mental effort or cognitive control. These terms frequently overlap with the term ‘controlled attention’. Each of these terms will be defined below along with ‘controlled attention’; a term that appears frequently in discussions of executive functioning and context processing.
Executive Functioning

Executive functioning is “a broad term that encompasses the processes that control and regulate low-level, routine behaviours and that are involved in planning and problem solving” (Avons, Nunn, Chan & Armstrong, 2003, p146). It enables both cognitive and behavioural adaptation to new and complex situations when highly automated and practiced processes are insufficient. Most daily activities require little cognitive effort. Some situations, however, require adaptation through cognitive control mechanisms to produce correct and appropriate behaviours. For example, the process of operating and driving a car every day becomes well practiced and routine, requiring little cognitive effort. However, when the car is replaced by a new and different model, control mechanisms are necessary to adapt to the different location and sensitivity of levers and buttons.

Executive functioning has traditionally been conceptualised as a unitary construct, for example as a central executive (Baddeley, 1986) or a supervisory attentional system (Norman & Shallice, 1986). However, a number of separate functions have been attributed to executive processes. Collette, Hodge, Salmon and van der Linden (2006), for example, suggest that these might include inhibition of prepotent responses, initiation of behaviour, planning of action, hypothesis generation, cognitive flexibility, judgment and decision making, and feedback management. However, the degree to which executive functioning is unitary, that is, reflecting the same underlying mechanism or ability is arguable. For example, Miyake, Friedman, Emerson, Witzki and Howerter (2000) argued that their latent variable analyses indicate that executive functions consists of separable functions (i.e. shifting, updating and inhibition) that share some commonality. Miyake et al. (2000) proposed that that these three executive sub-functions (shifting, updating and inhibition) might all require controlled attention in the maintenance of goal and context information in working memory.

Controlled Attention

Controlled attention is defined by Kane, Bleckley, Conway and Engle, (2001) as “an executive control capability: that is, an ability to effectively maintain stimulus, goal, or context information in an active, easily accessible state in the face of interference, to effectively inhibit goal-irrelevant stimuli or responses, or both” (p180). More specifically, Engle, Kane and Tuholski, (1999) conceptualised controlled attention as the capacity of
working memory, which along with two other elements, 1. a store in the form of long term memory traces active above threshold and 2. processes for achieving and maintaining that activation, make up the ‘working memory’ system. Their model views the capacity of working memory not as a memory store but as “the capacity for controlled, sustained attention in the face of interference or distraction” (Engle, et al., 1999, p104).

**Context Processing**

The definitions of controlled attention make frequent reference to context information. Hemsley (2005) identified a number of factors that can be defined as ‘context’, which may be relevant to any cognitive model that uses it. Firstly, both temporal and spatial context can influence performance. In paradigms of experimental cognitive psychology the temporal context can, for example, refer to stimulus onset asynchrony (SOA), that is, the time between the presentation of a stimulus and the requirement of a response. Similarly, the spatial context can refer to the presentation location of stimulus within the visual field. Hemsley (2005) further notes that the parameters of the temporal or spatial relationship may crucially affect the nature of their influence, as seen, for example, in priming. Priming involves the presentation of a prime stimulus that is replaced at its offset by a target stimulus. The relationship between the prime and target, including both temporal and spatial, can affect performance of identifying the target. The time delay separating the offset of the prime and onset of the target (i.e. the temporal context) typically affects a semantic priming effect (Neely, 1991). Furthermore, manipulations of the spatial context, for example, by presenting the target in a different location to the prime, influence repetition priming effects (e.g. Lachter, Forster and Ruthruff, 2004). Hemsley (2005) also highlights that context can have both facilitatory and inhibitory effects such as those seen in tasks of response competition. For example, in the Stroop colour word task (Stroop, 1935), colour word stimuli are presented either congruently or incongruent with the print colour. Performance at naming the colour of the print is typically facilitated when the context is congruent and inhibited when the context is incongruent. Hemsley (2005) notes that a further distinction can be made between ‘global’ and ‘local’ contexts. For example, the global context is provided by the entirety of an organism’s experience and history while the local context is provided by procedures of a specific task. Context can also be “interactive”, such as a prime-target semantic association that facilitates target identification in semantic priming, but also “independent”, such as the spatiotemporal association in priming but not the semantic one.
These definitions of context are only a sample of those highlighted by Hemsley (2005) and indicate how the processing of contextual information provides the basis for goal directed behaviour. Most of the context factors defined above make reference to their relevance in paradigms of experimental psychology. However, it must be highlighted that contextual factors provide the basis for controlled cognition and goal directed behaviour in naturalistic settings. For example, a zoo or the great outdoors might provide the context that determines fight or flight reactions to confronting a dangerous wild animal. Similarly, such a reaction in the great outdoors might be mediated by the environmental contexts, such as spatial (i.e. is the animal near or far) and temporal (i.e. is the threat immediate or more distant), global context, such as personal history and experience (i.e. has the threat been encountered before and was it successfully subdued at previous encounters) and also the interaction of global and environmental contexts (i.e. the threat is near but can be subdued therefore fight).

Cohen and Servan-Schreiber (1992) made reference to an ‘internal representation of context’ which they defined as ‘information held in mind in such a form that it can be used to mediate an appropriate behavioural response. This can be a set of task instructions, a specific prior stimulus, or the result of processing a sequence of prior stimuli’ (p. 46). They proposed that a single mechanism responsible for the processing of context can account for functions similar to the three proposed executive sub functions (shifting, updating and inhibition) studied in Miyake et al.’s (2000) latent-variable analyses. Cohen and Servan-Schreiber (1992) argued that this context processing mechanism, operating under different task conditions, underpins ‘attention’ (selection and support of task-relevant information for processing), ‘active memory’ (on-line maintenance of such information), and ‘inhibition’ (suppression of task-irrelevant information) (see also Cohen, Barch, Carter & Servan-Schreiber, 1999). As with executive functioning, the prefrontal cortex is proposed to serve this specific context processing function in cognitive control (Miller & Cohen, 2001). Attention, inhibition and active memory all “depend on the representations of goals and rules in the form of patterns of activity in the PFC [prefrontal cortex] which configure processing in other parts of the brain in accordance with task demands” (Miller & Cohen, 2001 p. 170). The processing of context is therefore an executive process that is similar to ‘controlled attention’ and as such, can account for performance on several tasks of executive functioning and inhibition and can also account for deficits observed in schizophrenia.
Cognitive Deficits in Multidimensional Schizophrenia/Schizotypy

The search for a unifying core deficit in schizophrenia is typically confounded by the tendency to either examine cognitive deficits in groups defined as ‘schizophrenic’ (i.e. as a unitary construct) or in groups characterised by an arbitrary number of traits or symptoms. For example, Basso, Nasrallah, Olsen and Bornstein (1998) highlight that “many of these [correlational] studies subsumed disorganised symptoms within measures of positive symptoms thereby obscuring any potential relationship between disorganised symptoms and neuropsychological impairment” (p100). However, regardless of the number of schizophrenic symptom clusters examined, the negative symptoms of schizophrenia are consistently associated with cognitive deficits while the positive psychotic symptoms are not (e.g. Buchanan et al., 1994; Brekke, Raine & Thomson, 1995; Basso et al., 1998).

One such study used a battery of measures to examine cognitive correlates of positive, negative and disorganised symptoms of schizophrenia (Basso et al., 1998). It found that negative symptoms were associated with deficits involving intelligence (measured by WAIS-R), executive functioning (measured using the Wisconsin card sorting task and trail making A and B), memory, sustained-attention and sensory-motor functions. Disorganized symptoms were also found to be correlated with decreases in intelligence, attention-span and sensory-motor function. However, psychotic positive symptoms were unrelated to cognitive deficits generally and were found to be associated with better performance on executive functioning measures including the Wisconsin card sorting task and trail making A (see Table 6 below).

Two recent meta analyses support these findings (Ventura, Helleman, Thames, Koellner & Nuechterlein, 2009; Dibben, Rice, Laws & McKenna, 2009). The first conducted by Ventura et al., (2009) included 73 studies, with a total of 6519 participants and examined neurocognitive functioning in schizophrenia. They defined neurocognition as “cognitive processes that are measurable with structured neuropsychological tests” (p191) and included studies that examined any 6 specific domains of cognitive functioning: speed of processing, attention/vigilance, working memory, verbal learning, visual learning, and reasoning and problem solving. They only included studies that distinguished between positive and negative symptoms and excluded those that examined disorganised symptoms or those that used measures that combine disorganisation with positive symptoms such as the Positive and Negative Symptom Scale (PNSS: Kay, Fiszbein & Opler, 1987). Ventura et al., (2009) found that the negative symptoms of schizophrenia were significantly
negatively correlated with neurocognitive functioning. However, positive symptoms were unrelated to measures of neurocognitive functioning.

Table 6
Findings from studies examining cognitive deficits in the symptom dimensions of schizophrenia and neurocognitive deficits in the trait dimensions of schizotypy

<table>
<thead>
<tr>
<th>Cognitive deficits in multidimensional schizophrenia (Basso et al., 1998)</th>
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<tbody>
<tr>
<td><strong>Negative symptoms</strong></td>
</tr>
<tr>
<td>Intelligence</td>
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<tr>
<td>Executive Functioning</td>
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<td>Memory</td>
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<td>Sustained Attention</td>
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<td>Sensory motor function</td>
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<tr>
<th>Neurocognitive profiles of positive and negative Schizotypy (Dinn et al., 2002)</th>
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<tr>
<td><strong>Negative Schizotypy</strong></td>
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<td>Executive dysfunction</td>
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A similar meta analyses, conducted by Dibben et al., (2009), examined 88 studies that focused specifically on the association of executive dysfunction with the negative, disorganised and positive symptoms of schizophrenia. They included studies that used numerous test of executive functioning, including, among others, measures of shifting, inhibition, updating, working memory and verbal fluency. Dibben et al.’s (2009), results were similar to Ventura et al. (2009) as they found executive dysfunction in schizophrenia not to be associated with positive symptoms but with negative and also disorganised symptoms. These findings have direct implications for the hypothesis that dysfunctions of the central executive that result in a disability to appropriately process contextual information represent a core deficit in schizophrenia. Neurocognitive deficits, specifically executive dysfunction, might be involved in the development of positive psychotic symptoms (see Hemsley, 2005) but they are not directly related to them.
If schizotypy is a sub-clinical form of schizophrenia, then similar distinct patterns of neurocognitive deficits should also be expected in the multidimensional schizotypal traits. A search of the literature revealed few studies examining neurocognitive correlates in multidimensional schizotypy. One study of note (Dinn, Harris, Aycicegi, Green & Andover, 2002), examined cognitive and neurocognitive correlates with the positive and negative schizotypy traits as measured by the interpersonal difficulties (negative traits) and cognitive and perceptual distortion (positive traits) subscales of the Schizotypal Personality Questionnaire-B (SPQ-B, Raine & Benishay, 1995). Although the SPQ-B includes a subscale measure of disorganisation, Dinn et al., (2002) did not report associations between this schizotypy trait dimension and the measures of neurocognition.

Dinn et al., (2002) used a battery of cognitive measures as well as measures of clinical states and other personality traits. They found that negative schizotypy, reflected by high scores on the SPQ-B interpersonal difficulties subscale, was associated with increased social anxiety, frontal executive dysfunction and obsessive compulsive phenomena. Negative schizotypy was not, however associated with measures of temporolimbic dysfunction, impulsivity and antisocial behaviour. In contrast, positive schizotypy, as measured by the SPQ-B cognitive and perceptual distortion subscale, was associated with measures of temporolimbic dysfunction, impulsivity, antisocial behaviour and disinhibition but not with measures of frontal executive functioning or measures of generalised and social anxiety (see Table 6 above).

It would seem that the executive dysfunction that is reliably associated with the negative symptoms of schizophrenia is also present in sub-clinical groups with many negative schizotypal traits. This suggests that executive dysfunction is an endophenotype of the negative symptoms of schizophrenia as it can be detected across degrees of clinical compensation. However, the Dinn et al. (2002) study is but one example and an additional body of evidence is required to draw firm conclusions. If executive dysfunction is an endophenotype of negative schizophrenia/schizotypy then they should be negatively associated with a range of specific executive functioning measures. The following section will therefore attempt to find support for a parallel executive functioning deficit in negative schizotypy and negative schizophrenia by reviewing results from studies that use the Wisconsin Card Sorting Task (WCST). The WCST assesses executive functioning and has been used widely in exploring such deficits in schizophrenia and schizotypy.
Wisconsin Card Sorting Task (WCST)

The Wisconsin Card Sorting Task (WCST) involves the presentation of a series of cards containing figures that vary in ‘shape’, ‘colour’ and ‘number’. Participants are required to sort the cards into piles according to one of the three stimulus categories the experimenter has in mind (e.g. ‘sort the cards by colour’). Subjects are not explicitly told the sorting rule but are given feedback for each card as to whether or not they have sorted it properly. Subjects typically discover this rule quickly. Once they have demonstrated that they know the rule (i.e. by correctly sorting a certain number of cards in a row) the experimenter unexpectedly switches the rule to another category (e.g. ‘sort the cards by shape’), which the subject is required to discover through the feedback as to whether or not they have sorted it properly. The task can be scored in a number of ways thus providing multiple dependent measures. The most frequently reported measure is perseverative errors, which occurs when the participant persists in using the old rule despite feedback indicating that the rule is incorrect. This measures the participants’ sensitivity to contingent feedback. The number of categories achieved is also frequently reported and is a measure of the overall success at the task. Furthermore, failure to maintain set measures the loss of the correct sorting rule and is thought to be a principle measure of working memory.

Successful performance on the WCST can be viewed as requiring the inhibition of previously appropriate behaviours (i.e. inhibiting the old sorting rule when it become redundant), the updating of rules that guide goal directed behaviour (i.e. sort by the new rule) and the shifting from one response set (e.g. colour) to another (e.g. shape) and is considered to be a measure of executive functioning. Although Miyake et al. (2000) found that perseverative responding on the WCST was most related to the executive sub function shifting, they further suggested that that the task requires a ‘controlled attention’ capacity (Engle et al., 1999). Controlled attention is defined above as an executive control ability enabling the effective maintenance of stimulus, goal, or context information in working memory to effectively inhibit goal-irrelevant stimuli or responses. In support, Cohen and Servan-Schreiber (1992) also suggested that failure to use contextual information would result in performance deficit on the WCST. Contextual information on the WCST is the feedback provided by the experimenter that enables the learning of a new rules and the overcoming of a response pattern that was correct on previous trials. Furthermore, consistent with the hypothesis that intact executive processing is required for successful performance on the WCST, patients with frontal lobe damage perform poorly and tend to display perseverative responding (e.g. Robinson, Heaton, Lehman & Stilson, 1980).
Although these patients are typically able to discover the first rule easily, they have difficulty switching to a new rule and continue to sort the cards according to the old rule.

The WCST has been extensively used in the studies of executive functioning in both schizophrenia and schizotypy. Examination of these data may provide further specific evidence for distinct cognitive deficit associations with the symptom/trait dimensions of schizophrenia and schizotypy and provide support for a parallel executive functioning deficit in negative schizophrenia and negative schizotypy. Patients diagnosed with schizophrenia typically achieve fewer categories and perseverate in responding when completing the WCST (e.g. Everett, Lavoie, Gagnon & Gosselin, 2001; Hartman, Steketee, Silva, Lanning & Andersson, 2003). These deficits are primarily associated with the negative symptom clusters of schizophrenia in studies approaching schizophrenia as a dual construct (Berman et al., 1997) making a distinction between positive and negative symptoms, and as a tri construct (Basso et al., 1998), where a distinction is made between positive, negative and disorganised symptoms. Furthermore, a meta analyses of 16 studies found worse performance on the WCST to be associated with negative symptoms and disorganised symptoms but not positive symptoms (Nieuwenstein, Aleman & de Haan, 2001). These results indicate that the negative symptoms of schizophrenia are associated with poor performance on the WCST and support findings outlined above that executive or controlled attention (or context processing) deficits are associated with the negative symptoms but not with the positive symptoms of schizophrenia.

Consistent with a schizophrenia spectrum of disorders, deficits on the WCST, including fewer numbers of categories achieved (Trestman et al., 1995) and perseverative responding (Poreh, Ross & Whitman, 1995; Suhr, 1997) are also seen in schizotypy. However, there is some inconsistency regarding which schizotypal trait dimension is associated with poor performance on the WCST. For example, Lenzenweger and Korfine, (1994) reported that fewer numbers of categories achieved, perseverative responding and a failure to maintain set, that is, the loss of the correct sorting rule, was associated with positive symptoms, as measured by the Perceptual Aberration Scale (PAS; Chapman, Chapman and Raulin, 1978), when used as a unitary measure of schizotypy. Studies approaching schizotypy as a dual construct have found perseverative responding and a lower number of categories achieved to be associated discreetly with the negative trait dimension of schizotypy (Franke, Maier, Hardt & Hain, 1993; Laurent et al, 2001; Laurent et al., 2000; Diforio, Walker & Kestler, 2000). Others, however, have found that both positive and negative trait dimensions are associated with perseverative responding (Gooding, Kwapil & Tallent,
1999) and with a lower number of categories achieved (Gooding, Tallent & Hegyi, 2001; Gooding et al., 1999). Two studies have found differential deficits associated with positive and negative trait dimensions with lower number of categories achieved being associated with negative dimension and failure to maintain set being associated with positive dimension (Daneluzzo et al., 1998; Tallent & Gooding, 1999). Only one study has been conducted exploring deficits on WCST in three dimensions of schizotypy (Suhr & Spinagle 2001) that included positive, negative and disorganised schizotypy. It found that a lower number of categories achieved were associated only with the negative schizotypal trait dimension.

Poor performance on the WCST is therefore associated with higher schizotypy scores. The inconsistencies regarding which schizotypy dimension is associated with such performance deficits could be due to a number of factors including the schizotypy measure used, the number of dimensions examined and idiosyncratic differences between studies in the administration of the WCST. A further possibility is that the cognitive deficit seen in schizophrenia might be attenuated in schizotypy and these attenuated deficits result in different behavioural effects.

**Conclusions**

A weakening of the ability to process context is a currently favoured hypothesised core cognitive deficit in schizophrenia (e.g. Cohen and Servan-Schreiber, 1992). Such a deficit is thought to be underpinned by executive dysfunction of the prefrontal cortex (Miller and Cohen, 2001). This brief and limited review has presented evidence supporting such a proposition. Executive dysfunction, also termed a ‘controlled attention’ deficit, which underpins a difficulty in maintaining contextual information, may therefore be an endophenotype of the schizophrenia spectrum of disorders. Such an endophenotype may primarily characterise the negative symptom dimension of schizophrenia, as the negative symptoms are specifically associated with neurocognitive deficits and poor performance on measures of frontal executive dysfunction (Dibben, et al., 2009; Nieuwenstein, Aleman & de Haan, 2001; Ventura, et al., 2009). Although evidence from studies examining executive dysfunction in schizotypy generally support these conclusions there are some inconsistencies regarding which schizotypy dimensions is associated with executive dysfunction. This might reflect procedural differences between studies or possibly that different processes or mechanisms are involved in the cognitive deficits of schizotypy.
As noted by Hemsley (2005), a deficit in context processing can explain both positive (hallucination and delusions) and disorganised symptoms. However, despite the hypothetical role of the prefrontal cortex in context processing (Miller and Cohen, 2001) and an executive dysfunction association with the negative symptoms of schizophrenia (e.g. Dibben, et al., 2009), a deficit in context processing has not been used or hypothesised to explain the negative symptoms of schizophrenia.

Recently, however, it has been suggested that aberrant context processing may be linked to social cognition deficits in schizophrenia. Context processing is thought be involved in the acquisition and maintenance of social-cognitive skills (Green, Uhlhaas & Coltheart, 2005). For example, impaired perception of implicit social information, as measured by social cue perception, has been found to be associated with verbal working memory and executive dysfunction as measured by the WCST (Lancaster, Evans, Bond & Lysaker, 2003). It could be theorised that social withdrawal, often observed in the negative symptoms schizophrenia, might result from a core executive dysfunction resulting in social cognitive deficits. It is unclear, however, how such a context processing deficit might account for the affective component of schizophrenia, which is a central characteristic of negative symptoms. Affective deficits might even be the core aetiological component of negative symptoms and be the underlying neurophysiological cause of a context processing deficits.

Park, Lee, Folley and Kim (2003) noted that affect is likely to influence all levels of perceptual and cognitive processing. For example, Ashby, Isen and Turken, (1999) proposed that positive affect can alter a wide range of cognitive processes via moderately increasing dopaminergic action. Affective states can selectively influence cognition related neural activity in the lateral prefrontal cortex (LPFC) (Gray, Braver & Raichle, 2002); an area of the brain thought to be involved in executive processes. Gray et al., (2002) used a continuous performance task, called the 3-back task, thought to measure the updating of working memory. The 3-back task involves the presentation of a series of stimuli and the participant has to indicate whether the current stimulus matches that from 3 steps earlier in the sequence. Gray et al. (2002) used it to examine the influence of an induced emotional state (pleasant vs. unpleasant) on performance of verbal and nonverbal (words vs. faces) versions of the task. They found an emotional state by stimulus type cross over interaction in both behavioural performance and neural activity in the LPFC measured using an fMRI scanner. On the word 3-back task behavioural performance was enhanced by a pleasant emotional state but impaired by an unpleasant state. Conversely,
performance on the face version of the task was impaired by a pleasant state but enhanced by an unpleasant state. Furthermore, neural activity in the LPFC was greatest during both the face-pleasant and word-unpleasant conditions. There were no main effects of either emotional state or task version suggesting that the functional specialization was lost, and emotion and cognition conjointly and equally contributed to the control of thought and behaviour.

The interaction of cognition and emotion in goal directed behaviour might be particularly disrupted in schizophrenia/schizotypy, as they are associated with both an executive cognitive dysfunction and an emotion processing deficits. A detailed review of emotion processing deficits in schizophrenia/schizotypy is however necessary in order to make any meaningful predictions regarding the nature of possible deficits in the interaction of cognitive and emotion.

1.5: Emotionality in Schizophrenia/Schizotypy

Bleuler (1911/1950) and Kraeplin (1904) (cited in Kring, Kerr, Smith & Neale, 1993) conceptualised diminished emotional experience as a fundamental symptom of schizophrenia. Meehl (1962) also considered diminished capacity to experience pleasure as a ‘quasi-pathognomonic sign’ of schizophrenia. According to Meehl’s model, anhedonia was the expression of a genetically based defect in the limbic brain system involved with reward that led to an “aversive drift” (i.e. a general shift of affectivity toward the aversive or negative end). The following review will examine several aspects and approaches to emotion processing in schizophrenia/schizotypy: 1) expressed emotions, 2) appetitive and consummatory pleasure deficits, 3) physiological evidence, 4) impact on memory, and 5) meta emotions.

Expressed Emotions

Suslow Roestel, Ohrrmann and Arolt (2003) note that research on affective deficits in schizophrenia has focused on emotional expression corresponding to the DSM definition of flat affect as “a restriction in the range and intensity of emotional expressivity” (DSM-IV: APA, 1994). From a behavioural and an external observation viewpoint, patients with a diagnosis of schizophrenia appear to experience diminished emotionality. Patients with a
diagnosis of schizophrenia, and especially those with blunted affect, show reduced facial expressiveness when responding to positive and negative emotional stimuli, but typically report experiencing as much positive and negative emotions as control groups (Berenbaum & Oltmanns, 1992; Kring, et al., 1993; Kring & Neal, 1996). However, the use of ‘experience sampling’, a random time sampling technique, reveals that those with a diagnosis of schizophrenia do report more intense negative emotions and less intense positive emotions compared to healthy controls (Myin-Germeys, Delespaul & deVries, 2003). Furthermore, and counter to intuition, the intensity of these subjective emotional experiences did not differ between patients with a diagnosis of schizophrenia with and without affective flattening (Myin-Germeys et al., 2000).

Suslow et al. (2003), however, found that that the frequency of emotional experience does differ between patients with a diagnosis of schizophrenia who had been classified into ‘affective’ subgroups. Patients displaying predominantly negative symptoms, such as anhedonia and affective flattening, experienced the emotions of ‘interest’ and ‘joy’ less frequently than healthy non-schizophrenic subjects and less frequently than a group of patients with a diagnosis of schizophrenia presenting the most ‘normal’ hedonic capacity. Furthermore, all of the schizophrenic subgroups examined by Suslow et al. (2003) (i.e. the flat-affect group, anhedonic group and the group with the most ‘normal’ hedonic capacity) experienced the emotions of ‘fear’ and ‘disgust’ more frequently than healthy non-schizophrenic subjects.

Suslow et al. (2003) hypothesised that experiencing a low frequency of positive emotions (i.e. joy and interest) could underlie flat affect expression and social withdrawal seen in the negative symptoms of schizophrenia. Suslow et al. (2003) further suggested that the more frequent experience of negative emotions (i.e. fear and disgust) might further add to withdrawal and flat affect. ‘Fear’ might be a strong motivator prompting avoidance and escape from threatening situations while more frequently occurring emotion of ‘disgust’ could indicate a stronger need to defend from interpersonal infringement. Suslow et al. (2003) further argue that the pattern of emotional experience in anhedonia (i.e. ‘joy’ and ‘interest’ less frequently and ‘fear’, ‘sadness’, ‘shame’ and ‘guilt’ more frequently) is consistent with Meehl’s (1962, 1989, 2001) model of anhedonia. In Meehl’s view, an imbalance between appetitive and aversive brain centres leads to a shift of affectivity toward the aversive or negative end of a continuum of affective states. In support of this, other studies have reported that anhedonia reported in patients with a diagnosis of
schizophrenia were negatively correlated with trait positive affect and positively correlated with trait negative affect (Blanchard, Mueser & Bellack, 1998).

Similar conclusions were offered by Horan, Green, Kring and Nuechterlein (2006). They found that patients with a diagnosis of schizophrenia reported higher levels of unpleasant emotions during presentation and recall of both pleasant and neutral stimuli than the control group. Such findings are consistent with a number of previous studies that reported higher levels of unpleasant emotions in patients with a diagnosis of schizophrenia during exposure to both unpleasant and pleasant stimuli (Earnst & Kring, 1999; Kring & Neal, 1996). Horan et al. (2006) suggested that disturbance in emotion regulation may be a core characteristic of those with a diagnosis of schizophrenia as they may be unable to ‘downregulate’ unpleasant emotions, that is, to reduce their intensity even when in an apparently enjoyable experience. This might undermine the adaptive benefits of pleasant emotions for cognition, social functioning and resilience to stress (e.g. Tugade & Fredrickson, 2004) and perhaps to the perpetual avoidance of enjoyable activities.

In sum, although the negative symptoms of schizophrenia are associated with reduced emotional expressivity, patients who present these negative symptoms typically report experiencing as much positive and negative emotions as control groups. However, the intensity and frequency of emotional experience does differ between control groups and groups with a diagnosis of schizophrenia who present with primarily negative symptoms. Those with a diagnosis of schizophrenia seem to experience less frequent and less intense positive emotions and more frequent and more intense negative emotions. Such experiences might result in the avoidance of enjoyable activities and result in some of the cognitive and social functioning deficits typically seen in the negative symptoms of schizophrenia.

In support of a schizotypy-schizophrenia continuum, a parallel pattern of reduced positive affect and increased negative affect is also observed in participants with anhedonic personality traits. This indicates that the pattern of emotional experience associated with the negative symptoms of schizophrenia also occurs before the development of a schizophrenia illness and are therefore not a consequence of other negative symptoms. Furthermore, such a pattern of emotional experience in trait anhedonia might even contribute to the decompensation process that result in other cognitive and social functioning deficits seen in schizophrenia by undermining the adaptive benefits of pleasant emotions for cognition, social functioning and resilience to stress.
Appetitive and Consummatory Pleasure Associations with Anhedonia

Anhedonia is an inability to experience pleasure from normally pleasurable life events such as eating, exercise, and social/sexual interactions. Given the evidence presented above, it might be expected that appetitive pleasure - the pleasure in ‘wanting’ that reflects the anticipation of consumption or experience of pleasant stimuli or events - and consummatory pleasure - the pleasure in ‘liking’ that reflects actual consumption or experience of pleasant stimuli or events (e.g. Berridge & Robinson, 2003) - would be diminished in schizophrenia and especially in those who report a high degree of anhedonia. Reductions in ‘wanting’ and ‘liking’ might interfere with behavioural conditioning systems and leave individuals less sensitive to rewards during the learning of stimulus-reward associations more and sensitive to the effects of punishment during the learning of stimulus-punishment associations (e.g. Gray, 1990, 1994).

As reported above, positive emotions are experienced less intensely (Myin-Germeys et al, 2000) and less frequently (Suslow et al., 2003) and negative emotions are experienced more intensely (Myin-Germeys et al., 2000) and more frequently (Suslow et al., 2003) in patients with a diagnosis of schizophrenia and particularly in those experiencing predominantly negative symptoms. These findings are suggestive of reductions in ‘liking’ or of a consummatory pleasure deficit. Furthermore, as expected from reduced anticipation of reward, anhedonia is frequently associated with reduced total scores on the Behavioural Activation System (BAS) Scale (Caver and White, 1994), a measure of approach motivation and sensitivity to reward, and reductions on BAS subscales Reward Responsiveness, Fun Seeking and Drive (Applegate, El-Deredy & Bentall, 2009; Germans & Kring 2000; Horan et al., 2006).

A more direct examination of the relationship between anhedonia, as measured by the Scale for Physical Anhedonia (Chapman, Chapman & Raulin, 1976), and appetitive and consummatory pleasure (Germans & Kring 2000) had participants rate their degree of pleasure/displeasure and the degree of arousal they experienced at the presentation of written descriptions of positive, negative and neutral tactile, gustatory and visual cue stimuli. For example, a description of a positive gustatory cue was the phrase “a golden-brown, freshly baked, chocolate chip cookie”. Cues were intended to elicit positive, negative or neutral states in anticipation of a sensory experience. Participants were then presented with the actual positive, negative and neutral tactile (i.e. an object to touch), gustatory (e.g. a biscuit to eat), and visual stimuli (i.e. a picture) and requested to rate their
degree of pleasure/displeasure and the degree of arousal they experienced at the presentation of each stimulus.

In one study that used the procedures outlined above, Germans and Kring (2000) reported that physical anhedonia was associated with reductions on a number of measures that indicate reductions in appetitive approach motivation. These include reduced scores on the Positive Affect subscale (PANAS-X, GEN; Watson & Clark, 1991) that is indicative of diminished positive affect, diminished intensity of emotional experience as measured by the Emotional Intensity Scale (EIS; Bachorowski & Braaten, 1994) and diminished self report of approach motivation, that is, reductions on BAS total score, BAS subscales Reward Responsiveness and Fun Seeking. It was therefore expected that decreased approach motivation would be associated with lower rating of pleasure to cues and actual stimuli indicating diminished experience of both appetitive and consummatory pleasure. However, Germans and Kring (2000) found that the physical anhedonia group did not differ to the control group on their self reported experience of pleasure to the sensory cues or actual sensory stimuli suggesting that both appetitive and consummatory pleasure were intact. A similar study also reported indirect correlational evidence suggesting that anhedonia was associated with reductions in reward responsiveness. However, measures of consummatory pleasure were unaffected in anhedonia when pleasant film scenes and pleasant foods were used as stimuli (Horan et al., 2006).

There appears to be a discrepancy between self-reports of reward responsiveness (i.e. appetitive pleasure or ‘wanting’) and self-reports of experienced pleasure to emotional cue stimuli (i.e. consummatory pleasure or ‘liking’). Typically, self-report measures of reward responsiveness are reduced and indicate reductions in appetitive pleasure. For example, Applegate et al. (2009) reported that introvertive anhedonia (i.e. the O-LIFE’s measure of negative schizotypy) was negatively associated with of reward responsiveness (i.e. BAS total score, and BAS subscales Reward Responsiveness, Fun Seeking and Drive) (see also Germans and Kring, 2000; Horan et al., 2006). However, self-report of the amount of pleasure experienced from sensory cue stimuli, including pleasant film scenes and pleasant foods, do not differ between anhedonic and control groups (Germans and Kring, 2000; Horan et al., 2006). Several possibilities could be offered for this discrepancy between self-report measures of reward responsiveness and self-reports of experienced pleasure to emotional cue stimuli. Firstly, report of subjective experience may not be adequately sensitive enough to detect differences in emotional activity between anhedonic and control participants. For example, if an anhedonic individual has attenuated pleasure from all
foods then they may rate a highly pleasurable item, such as a cake, as being relatively more pleasurable. Secondly, the frequent use of cue stimuli in the reviewed studies may have primed or habituated responses to actual stimuli. Thirdly, subjective rating of stimuli could be influenced by an individual’s opinion of the societal norms for those stimuli. For example, a cake may carry positive value or schema, as we receive them on birthdays and other special occasions, even if an individual may not receive pleasure from consuming it. Furthermore, watching a film clip from a film known to be from a comedy genre may prime a positive expectation and response.

Support for the existence of blunted affective subjective emotional experience in anhedonia does however come from the observation that differences in subjective valence ratings, of positive stimuli exists between groups scoring high and low on anhedonia (Mathew & Barch, 2006). Valence refers to the attractiveness (positive valence) or aversiveness (negative valence) of an event, object or situation. Stimulus valence ratings involve subjectively rating stimuli on a valence scale, for example, the Self-Assessment Manikin (SAM; Lang, 1980) uses a 9 point scale to rate stimulus valence from a positive pole (e.g. a rating of 9), across a neutral rating (e.g. a rating of 5) to a negative pole (e.g. a rating of 1). Typically, those scoring high on a measure of anhedonia report reduced valence ratings of positive stimuli (Ferguson and Katkin, 1996; Fitzgibbon & Simons, 1992; Mathew & Barch, 2006), that is, they tend to rate positive stimuli as less positive than control groups. These studies used word and picture stimuli instead of film clips and food used by Horan et al. (2006) and German and Kring (2000). Words and pictures are simpler and more ambiguous than film clips and food and might require greater interpretation. Greater interpretation might trigger more subjectively held semantic information and therefore, as suggested by Mathews and Barch (2006), provide a more sensitive measure of individual differences in subjective emotional experience.

In sum, it might be expected that anhedonia would be associated with reductions in approaching and consuming appetitive stimuli. However, those who score highly on measures of anhedonia produce reductions on self report measures of sensitivity to reward but do not differ in their self reported subjective experience of pleasure to emotion eliciting cue stimuli (i.e. appetitive pleasure) or actual stimuli (i.e. consummatory pleasure). However, reduced valence rating of positive stimuli suggests the existence of blunted subjective experience in anhedonia. The inconsistencies between theory and data might have been due to methodology that relied on subjective reports of emotional experience and the use of ‘complex’ multi dimensional stimuli that might have primed responses.
Physiological Findings in Anhedonia

The use of physiological measures provides some direct evidence for an emotion cue processing deficit in anhedonia. For example, compared to a control group, participants scoring high on measures of anhedonia display reduced changes in heart rate when processing emotional stimuli (Ferguson & Katkin, 1996; Fitzgibbon & Simons, 1992; Fiorito & Simon, 1994). However, skin conductance differences are not found between groups scoring high and low on a measure of anhedonia (Ferguson & Katkin, 1996; Fitzgibbon & Simons, 1992; Fiorito & Simon, 1994). Furthermore, studies using an acoustic startle paradigm have also generated mixed findings. Allen, Trinder, Rae and Brennan (1995) reported that individuals scoring high on a measure of anhedonia generated a comparable startle effect to pleasant and neutral stimuli while the control group generated a larger startle effect to positive than neutral stimuli. However, Gooding et al. (2002) report similar changes in for high and low scorers on a measure of anhedonia in startle response to positive and negative emotional stimuli.

Perhaps these inconsistencies can be reconciled. Mathews and Barch (2006) suggested that inconsistencies in the physiological data might reflect a dissociation in anhedonia between the processing of arousal and valence. There is some evidence suggesting that heart rate tracks valence of emotional stimuli (e.g. positive vs. negative), while skin conductance tracks arousal irrespective of valence (e.g. high versus low arousal) (Fitzgibbon & Simons, 1992). As such, individuals reporting high levels of anhedonia show deficits in physiological indices linked to emotional valence (e.g. heart rate), but not arousal (e.g. skin conductance, Ferguson & Katkin, 1996; Fitzgibbon & Simons, 1992; Fiorito & Simon, 1994). There is also support for such dissociation with self-report measures of emotional cues. Both Fitzgibbon and Simons (1992) and Mathews and Barch (2006) found reductions in groups scoring high on anhedonia on self-reports of the degree of stimulus valence but not stimulus arousal. Fiorito and Simons (1994), however, report that self-report ratings of both stimulus valence and arousal were lower in individuals scoring high, compared to those scoring low, on a measure of physical anhedonia.

Physiological data provides some objective evidence of emotional processing deficits in anhedonia. These further suggest that there might be an emotion cue processing dissociation in anhedonia with intact arousal processing of emotional stimuli but deficits in valence processing. Although inconsistent, there is some supporting evidence that self-report ratings of valence are reduced but those of arousal are intact. The inconsistency in
the self-report data might however have been due to the imagery technique used by Fiorito and Simons (1994). Imagery involves the imagining of an emotional scene and might have result in a deeper level of processing and possibly relatively higher rating of arousal in the low introvertive anhedonia group. However, it is equally likely that the self report measures of valence and arousal were unreliable.

**Impact of Emotional Deficits on Memory**

Having subjects imagine an emotional scene can moderate an emotional response for low but not high scoring anhedonic groups. For example, Roedema and Simons (1994) reported no startle blink magnitude difference between groups scoring high and low on anhedonia during emotional cue stimulus presentation. However, during imagery the high anhedonia group had comparable startle blink modulation for positive and neutral stimuli while the control group produced a larger startle blink modulation for positive than for neutral stimuli.

After imagery, subjects scoring high on a measure of anhedonia rated both positive and negative imagery scenes as less arousing than a control group (Fiorito and Simons, 1994). Furthermore, control subjects’ heart rate acceleration was related to valence during both stimulus presentation and imagery, with negative stimuli/imagery being associated with greater heart rate acceleration than positive stimuli/imagery. During stimulus presentation participants scoring highly on a measure of anhedonia also demonstrate the same, though attenuated, greater heart rate acceleration for negative than positive stimuli. However, during imagery, the heart rates of the high anhedonia group failed to increase and remained at baseline.

Furthermore, when specifically instructed to imagine a positive situation from their past in which they felt wonderful and thought things were perfect, control subjects generated an emotion pattern resembling, what Fiorito and Simons (1994) referred to as, active (high arousal) joy. That is, increased facial electromyography (EMG), accelerated heart rate and heightened skin conductance. However, the high anhedonia group given the same instructions generated, what Fiorito and Simons (1994) referred to as a passive (low arousal) joy pattern. That is, increased facial EMG, decelerated heart rate (i.e. a reduction in valence) and lowered skin conductance (i.e. reduction in arousal). In support, when very specific imagery scripts were used that included detailed description of physiological
responses to emotional arousing situations, for example, “You are trembling with excitement…..” and “your heart races…..” (Fiorito & Simons, 1994, p515), then participants scoring highly on a measure of anhedonia produced an active joy emotion pattern similar to controls (Fiorito & Simons, 1994). Similarly Fitzgibbon and Simons (1992) reported that the viewing of colour slides also produced a similar active (high arousal) joy pattern of activity in both the high and low anhedonia groups.

These results suggest that a desynchronised emotional reaction among verbal (i.e. self report), behavioural (i.e. facial EMG) and visceral (i.e. heart rate) measures only occurs in high anhedonia groups when the stimulus has a degree of emotional ambiguity that requires participants to rely on their own memories to generate and imagine a positive emotional scene. Fiorito and Simons (1994) suggested that such a desynchronised response pattern might indicate that positive emotion prototypes are not represented in long term memory or that their representations are present but poorly integrated or incoherent. That is, representations that are coherent have strong associations in semantic memory and can therefore be accessed entirely even when the stimuli is highly degraded. In contrast, representations that are incoherent have weak associations and require a more direct match with the emotion-invoking stimulus before complete emotion processing can occur. Fiorito and Simons (1994) further suggested less overall coherence of long term memory emotion prototypes might account for the absence of a high and low anhedonia group difference in a synchronised emotional response when using colour slides (Fitzgibbon and Simons, 1992). Disruption in long term memory prototypes might also account for why high and low anhedonia group’s emotional response differences are not observed with film stimuli (e.g. Berenbaum, Snowhite & Oltmanns, 1987). Fiorito and Simons (1994) suggested the likelihood of activating emotion prototypes in long term memory would decrease as the emotion eliciting stimuli become more ambiguous and change from film clips to colour slides to text and then to imagery. Fiorito and Simons (1994), therefore, argued that subtle deficits between high and low scoring anhedonia groups should be most apparent when subjects are required to draw most heavily upon their own resources to produce the emotional response.

Fiorito and Simons (1994) further argued that the high anhedonia groups poorly integrated verbal, behavioural and visceral response profile and specifically the absent relationship between slide valence and the heart rate response during imagery may indicate that only the semantic information contained in the emotion network has been processed thereby resulting in a simple appraisal of stimulus content. In support, Kerns and Berenbaum
(2000) examined semantic and affective priming in individuals scoring highly on a measure of social anhedonia. They found that the anhedonia group were sensitive to the valence of targets of prime-target pairs while the control group were sensitive to the valence of primes. This suggested that the anhedonia group did not process primes affectively. Furthermore, the amount of semantic processing in the social anhedonia group was associated with processing of target valence. Kerns and Berenbaum (2000) suggested that the social anhedonia group processed the affective information in a semantically detailed but affectively shallow manner. As argued by Fiorito and Simons (1994), those who score highly on measures of social anhedonia may make a simple appraisal of stimulus content but are either unable to process stimuli affectively or refrained from affective processing, for example with a repressor strategy (e.g. Fox, 1994).

Incoherent representations of positive emotions might result in memories of positive stimuli and events being more difficult to retrieve but memories for negative stimuli being more easily retrieved. Positive memories might be unavailable to buffer against stressful or negative experiences thus increasing the salience of memories for negative stimuli. However, although Mathews and Barch (2006) found that social and physical anhedonia were associated with reduced valence ratings for both positive and negative emotional words, these reductions in valence processing did not effect performance on a later episodic memory recall and recognition task. This suggests that reduced valence ratings of emotional stimuli does not effect processes in memory encoding and recall. Self-reports of the arousal of word stimuli were however intact which Mathews and Barch (2006) suggested could have facilitated the successful incidental encoding and later recall of the emotional words. Horan et al. (2006) reported similar findings in participants with a diagnosis of schizophrenia. The schizophrenia group had a higher number of anhedonic traits than the control group but did not significantly differ in delayed recall of pleasant emotional experiences. This suggested that anhedonic traits do not result from deficiencies in memory processes.

In sum, participants who have many anhedonia traits do not rate imagined emotional scenes as arousing as control participants. Furthermore, unlike during stimulus presentation, positive and negative imagery scenes do not generate differences in the heart rate activity of individuals with many anhedonic traits. Effects that imagery elicit are most apparent in anhedonia when participants are asked to draw on their own personal resources to imagine an emotionally positive scene from their past. In such a circumstance, individuals with many anhedonic traits fail to generate synchronised verbal (i.e. self-
report), behavioural (i.e. facial EMG) and visceral (i.e. heart rate) responses. Such results might reflect a deficit in anhedonia of the representation of positive emotion prototypes in long-term memory or a semantic only processing of emotional information resulting in simple appraisal of stimulus content. This might result in memories of positive stimuli and events being more difficult to retrieve and thus being unavailable to buffer against stressful or negative experiences. As a result, memories for negative stimuli and events might be more readily available perhaps contributing to a general shift of affectivity toward the aversive or negative end of a continuum of emotionality.

**Meta Emotions**

If people high on anhedonia refrain from affectively processing stimuli with, for example, a repressor strategy (e.g. Fox, 1995), or are unable to process information affectively they may demonstrate aberrant meta-mood processing. Meta-mood processing is thought to reflect how people experience and process their emotions (Mayer and Gaschke, 1988). Mood can be experienced directly and at a reflective or meta level consisting of representations about the mood. Furthermore, the regulation of mood can occur consciously and unconsciously. At a highly conscious and self reflective level, individuals are aware of both mood and thoughts about the mood (i.e. the meta-experience of the mood). The ability to access feelings, to discriminate among feelings and to label those feelings are aspects of emotional processing that are important in order to use information conveyed by emotions adaptively.

Berenbaum et al. (2006) conducted correlational analyses of multidimensional schizotypy with aspects of meta mood processing including two facets of emotional awareness. The first being attention to emotions, referring to the extent to which an individual notices, thinks about and monitors their own mood. The second was clarity of emotions, which refer to how clearly an individual understands their emotions, discriminates among their emotions and can identify what they are feeling. Berenbaum et al. (2006) also examined correlates of multidimensional schizotypy with emotional intensity and instability and negative affect.

Berenbaum et al. (2006) found that elevated levels of negative affect were associated with interpersonal symptoms (negative schizotypy), which is consistent with previous findings of an anhedonia and negative affect association (Blanchard et al., 1998; Gooding et al.,
2002; Mathews & Barch, 2006); but they also found that elevated levels of negative affect were associated with cognitive perceptual symptoms (i.e. positive schizotypy). Furthermore, suspiciousness and cognitive-perceptual disturbances (i.e. positive schizotypy traits) were found to be associated with elevated emotional awareness and higher level of attention to emotion. A similar correlation is also reported by Kerns (2005) who found that participants scoring highly on measures of magical ideation and perceptual aberration (i.e. positive schizotypal traits) reported greater attention to emotions but also less emotional clarity than control participants. In contrast, Berenbaum et al., (2006) found attention to emotions to be negatively correlated with interpersonal symptoms (i.e. negative schizotypal traits) and suggested that low attention to emotion might make it difficult, or less appealing, to establish strong interpersonal ties, perhaps because attention to emotion may facilitate empathy and the ability to develop a sense of connection with others. Alternatively, Berenbaum et al. (2006) suggested that interpersonal difficulties may lead individuals to stop attending to their emotions or that a third variable, such as an avoidant coping style, contributes to both interpersonal problems and diminished attention to emotion.

In sum, while increased attention to ones emotions is associated with trait positive schizotypy, decreased attention to emotion is associated with trait negative schizotypy. However, it is unclear whether a reduction in attention to emotions is caused by, or, is a consequence of, negative schizotypal traits.

Conclusion

In conclusion, a variety of observations indicate the presence of emotional deficits in schizophrenia and specifically in negative symptomatology and anhedonia. Negative emotions are experienced more intensely and more frequently while positive emotions are experienced less intensely and less frequently. It has been suggested that this might underpin the social withdrawal and flat affect expression seen in the negative dimension of schizophrenia. Furthermore, patients with a diagnosis of schizophrenia experience heightened levels of unpleasant emotions during exposure to both unpleasant and pleasant stimuli. They may therefore be unable to downregulate unpleasant emotions while having positive experiences. This could undermine the adaptive benefits of pleasant emotions for cognition and social functioning.
Emotional deficits are only sometimes apparent in trait anhedonia when stimuli used to elicit an emotional reaction are simple (requiring greater interpretation) or when participants are required to draw on their own resources to produce an emotional response. Imagery fails to produce an integrated response profile among verbal, behavioural and visceral responses possible reflecting poor integration or incoherence of emotion prototypes in long term memory or reflecting a semantic only emotional stimulus appraisal in the absence of affective processing. Alternatively, anhedonics might refrain from affective processing by using a repressor processing strategy (e.g. Fox, 1994).

Meta mood processing further suggests that interpersonal difficulties, an aspect of negative trait schizotypy, are associated with less attention to emotion. However, as Berenbaum et al., (2006) suggests it unclear whether attention to emotion is the cause, effect or contributory factor of interpersonal difficulties.

1.6: Thesis Objectives

Despite negative symptoms being a central component of schizophrenia they are currently largely untreatable. A greater understanding of negative symptoms might therefore stimulate new theory and research direction. The current investigation therefore sought to identify cognitive endophenotypes associated with the negative symptoms of schizophrenia. The preceding introduction highlighted that the examination of executive dysfunction and cognition associated emotional cue processing might provide fruitful avenues of exploration. The current research also aimed to account for confounding variables that are typically associated with schizophrenia research such as medication, age of illness onset and illness duration. It therefore examined negative schizotypal traits in non-clinical populations, which was measured by the O-LIFE’s introvertive anhedonia dimension.

The investigation therefore began with three main objectives; 1) explore the possibly of a generalised executive deficit in introvertive anhedonia, 2) explore the possibility of an emotion cue processing deficit in introvertive anhedonia, and 3) explore possibility of an interactions between executive functioning and emotion cue processing in introvertive anhedonia.
The first objective was addressed in the following section (Chapter 2) using the Stroop colour word task (Stroop, 1935). The Stroop task was considered an appropriate and logical paradigm to address objective 1 as it is thought to require executive functions in inhibiting irrelevant stimuli and focusing attention (Lezack, 1995) and has been extensively used in previous studies examining cognition in schizophrenia and schizotypy. The second objective was addressed in Chapter 3 using three tasks that examine attentional biases to emotional cues: the emotional Stroop task (e.g. Williams, Mathews and MacLeod, 1999), an affective priming paradigm (Fazio, Sanbonmatsu, Powell & Kardes, 1986) and a dot probe task (MacLeod, Mathews and Tata, 1986). The emotional Stroop task is a variant of the Stroop colour word task and presents neutral words, emotional words and threat words instead of colour words. The task is thought measure biases of ‘attention’ to the semantic content of word stimuli. The affective priming paradigm presents prime and target stimuli that are either affectively congruent (i.e. having the same valence) or affectively incongruent (i.e. having opposing valences). One interpretation of the paradigm is that it involves a mechanism of response facilitation/competition similar to the classic Stroop colour word task and can be used to assess the strength of processing affective primes and targets. The dot probe paradigm simultaneously presents an emotional stimulus and a neutral stimulus that are followed at their offset by a small dot probe in the location just occupied by one of the stimuli. Responses to the dot probe assess attentional orientation towards emotional stimuli and attentional disengagement from emotional stimuli.

The third and final objective was addressed in chapter 4 using biconditional discrimination procedures. The acquisition of biconditional discriminations involves learning that a combination of stimuli and not individual stimuli predicts appetitive and aversive outcomes (e.g. if A then Y = appetitive outcome; if A then X = aversive outcome). This enabled the examination of the influence of outcome valence on both the executive cognitive processes involved in the acquisition of biconditional discriminations and the influence of outcome valence on the formation of new associations.
Chapter 2:

Executive Cognitive Processes in Introvertive Anhedonia
2.1: Introduction

This chapter will address objective 1 of the theses by exploring the possibility of a
generalised executive deficit in introverted anhedonia, the O-LIFE’s measure of negative
schizotypy. The Stroop colour word task (Stroop, 1935) will be used as it is thought to
require executive cognitive functions. It is one of the most studied measures of executive
functioning (see MacLeod, 1991 for a review) and has been used extensively to assess
cognitive functions in numerous clinical and sub-clinical populations. The following
review will define the Stroop colour word task, examine its use in studies investigating
cognition in schizophrenia and schizotypy and consider the specific cognitive processes
involved.

Stroop Colour Word Task and Schizophrenia

The Stroop colour word task involves the presentation of colour words that are incongruent
with the ink colour (i.e. word RED written in green ink) and congruent with the ink colour
(i.e. word RED written in red ink). In his original experiment, Stroop (1935) observed
three primary effects. First, naming colour words was faster than naming ink colours.
Secondly, incongruent ink colours did not interfere with colour word naming. Thirdly,
naming the ink colour of incongruent colour words produced an interference effect. Such
interference effects manifest as either longer reaction times or as an increase in the number
of errors whilst responding to the ink colour of an incongruent colour word (i.e. naming the
ink colour rather than the word colour). The asymmetry of interference (i.e. words
interfere with colour naming but colours do not interfere with word reading) suggests that
word meaning is extracted even when participants are attempting to inhibit its processing.
The effect is also present when words are presented below the level of conscious
awareness (Cheesman & Merikle, 1984) suggesting that word identification may be an
unavoidable automatic process. The task purports to measure frontal lobe executive
functioning involved in inhibiting irrelevant stimuli and focusing attention (Lezack, 1995)
and is frequently included in neuropsychological batteries as a measure of selective
attention. Frequently, however, little regard is given to the consequences of different
administration methods and to the interpretation of analyses based on various measures of
the Stroop effect (see Henik & Salo, 2004 for a detailed review).
Increased Stroop interference effect has been reported in patients with a diagnosis of schizophrenia when compared with ‘normal’ control groups (e.g. Ngan & Liddle 2000; Verdoux, Magnin & Bourgeois, 1995). However, similar sized interference effects have also been found in patients with a diagnosis of mania (McGrath, Scheldt, Welham & Clair, 1997) and depression (Everett, Laplante, & Thomas, 1989) suggesting that the task may not measure cognitive deficits that are unique in schizophrenia. Some of these studies have approached schizophrenia as a unitary construct (McGrath et al., 1997, Everett et al., 1989), which may mask deficits in cognition associated with different schizophrenia symptom subgroups. Positive psychotic symptoms and negative symptoms seem to be caused by unique pathophysiologies (e.g. Buchanan & Carpenter, 1994) that manifest as distinct deficits in cognitive functioning. Not making such symptom cluster distinctions when investigating cognitions in schizophrenia will therefore not provide interpretable information regarding the cause, nature and possible consequences on behaviour of specific deficits in cognition. Schizophrenia symptoms and Stroop effect associations are, however, dependent on the number and nature of symptom distinctions made. Some investigators categorising individuals based on a predominance of positive or negative symptoms found no difference in Stroop interference between the clustered groups (e.g. Penn, Hope, Spaulding & Kucera. 1994; Verdoux et al. 1995). Others however, making distinctions between three schizophrenia symptom clusters (i.e. positive, negative and disorganised), have found increased Stroop interference to be associated with disorganised symptoms (Liddle, Friston, Frith & Frackowiak, 1992; Moritz et al., 2001) and both disorganised and negative symptoms (Liddle & Morris, 1991). A further distinction has been made between ‘deficit’ schizophrenia, characterised as a predominance of primary enduring negative symptoms that are not related to transient or episodic factors, and ‘non-deficit’ schizophrenia, characterised by the absence of such enduring primary negative symptoms (Carpenter et al., 1988). Stroop interference is found to be increased in ‘deficit’ compared to both a ‘non-deficit’ schizophrenia group and a group of control participants (Buchanan et al., 1994).

The studies reported thus far used a list based version of the Stroop task (see Figure 2) where the dependant variable was either the total number of correct incongruent Stroop items named within a given period or the average speed of naming a predetermined number of incongruent items. This version of the Stroop task is susceptible to numerous additional internal and external confounding variables. For example, the card version presents lists of stimuli where additional cognitive processes would be involved in ignoring adjacent colour and word stimuli and in generating eye movement down columns of
stimuli. However, a single trial version of the task requires responses to colour word items presented individually. It has been argued to increase the task’s sensitivity (Carter, Robertson & Nordahl, 1992) as it enables the removal of error responses and response outliers from the reaction time data set.

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Figure 2. Card version of the Stroop colour word task.

Studies using a single trial version of the Stroop task do not typically observe an increase in the reaction time (RT) Stroop interference (i.e. mean RT to incongruent stimuli minus mean RT to neutral stimuli consisting of XXXX in various colours) in patients with a diagnosis of schizophrenia, implicating the absence of selective attention deficits. Instead, larger reaction time Stroop facilitation effects (i.e. mean RT to neutral stimuli minus mean RT to congruent stimuli) are observed (Barch, Crater & Cohen, 2004; Barch, Carter, Hachten, Usher & Cohen, 1999; Barch, Carter, Perlstein et al., 1999; Burbridge & Barch, 2002; Carter et al., 1992; Carter, Robertson, Nordahl, Oshoracelaya & Chaderjian, 1993; Carter, Mintun, Nichols & Cohen, 1997; Chen, Wong, Chen & Au, 2001; Cohen, Barch, Carter & Servan-Schreiber, 1999; Henik et al., 2002; Taylor, Kornblum & Tandon, 1996) often with a greater number of error responses to incongruent stimuli (Burbridge and Barch, 2002; Barch, Carter, Hachten et al., 1999; Barch, Carter, Perlstein et al., 1999; Carter et al., 1997; Chen et al., 2001; Cohen et al., 1999). This pattern of data might however reflect a common selective attention deficit in the ability to ignore the word dimension in neutral, congruent and incongruent conditions (Barch, Carter, Hachten et al., 1999).

Barch, Carter, Hachten et al. (1999) found that patients with a diagnosis of schizophrenia respond disproportionately slower when colour naming neutral stimuli as they change from colour patches (i.e. a patch of colour) to animal words (e.g. DOG) and then to colour neutral words (i.e. colour word that are not members of the response set) (see Figure 2).
Barch, Carter, Hachten et al. (1999) manipulated the amount of semantic information available in neutral stimuli in stages by presenting colour patches, animal words and colour word that were not part of the response set (see Figure 2). Due to the apparent automaticity of word reading (Cheesman & Merikle, 1984) it would be expected that reaction times to colour naming neutral stimuli and the number of errors would increase as the irrelevant dimension of neutral stimuli becomes more similar to the response set. A colour patch is a unidimensional stimulus that does not contain semantic information that can interfere with colour naming. Animal words, however, contain semantic information that will demand processing and subsequently interfere with colour naming. This interference will be small, as the semantic dimension is not related to the response set. However, neutral stimuli consisting of colour words that are not part of the response set will generate larger interference as the semantic information belongs to the same semantic category as exemplars of the response set. As such, reaction time facilitation with colour patches cannot be explained by semantic word information leading to slower reaction time responses in the neutral condition. Increase reaction time facilitation observed in patients...
diagnosed with schizophrenia (e.g. Burbridge & Barch, 2002) therefore supports the proposition that selective attention deficits lead to a greater influence of the word dimension in the congruent condition thus contributing to a speeding of reaction time responses and a larger facilitation effect.

The lack of increased reaction time interference in schizophrenia may also have resulted from relative slowing on neutral items. A slowing on neutral items would contribute to both a larger facilitation effect and smaller interference effect (see Figure 3). However, the absence of increased reaction time interference in schizophrenia may also be due to the increase in number of error responses to incongruent stimuli (Burbridge & Barch, 2002; Barch, Carter, Hachten et al., 1999; Barch, Carter, Perlstein et al., 1999; Carter et al., 1997; Chen et al., 2001; Cohen et al., 1999). It is typically assumed that the influence of word reading interferes with colour naming in the incongruent condition thereby slowing responses. However, selective attention deficits may be so severe in schizophrenia that they lead not just to slowing in reaction time in the incongruent condition but to actually responding to the word rather than the colour thereby producing increased errors (Barch, Carter, Perlstein et al., 1999).

**Explanation of Stroop Results in Schizophrenia**

Consideration of the Stroop task traditionally focuses on the inhibition of the prepotent response of word reading (MacLeod, 1991). However, Cohen and Servan-Schreiber (1992) propose that a reliable internal representation of context is also crucial to the task. In order to respond to the appropriate dimension of the stimulus, the subjects must hold in mind the task instructions for the trial. These provide the context for disambiguating the stimulus and generating the correct response. The task instruction must be represented internally as the stimuli do not indicate which task is to be performed. A weakening in the ability to process context, which is underpinned by executive dysfunctions of the prefrontal cortex (Miller & Cohen, 2001), is a hypothesised core cognitive deficit in schizophrenia (e.g. Cohen and Servan-Schreiber, 1992). Hemsley (2005) notes that such a context processing deficit provides a plausible link to a range of symptoms and can account for both working memory and inhibitory processing deficits, which are considered to be central cognitive processes impaired in schizophrenia.
Hypothesised context processing involvement in the Stroop task is based on Cohen, Dunbar and McClelland’s (1990) connectionist model. The model proposes that both speed of processing and interference effects are related to a common, underlying variable, which they called **strength of processing**. The model assumes that greater experience in word reading than colour naming provides stronger connections between orthographic inputs and word reading than between colour input and colour naming leading, therefore, to a prepotency of word reading over colour naming. This was demonstrated in the simulation by providing a greater amount of training to word reading thereby developing stronger pathways for the processing of word information leading to faster word reading than colour naming. The internal representation of context was represented as a pattern of activation in the task demand units. Increasing the amount of attention allocated to a task (i.e. colour naming or word reading), by increasing activity in the relevant task demand unit, was directly responsible for the model selecting one pathway for the processing of information and not the other. Colour naming needed more attention than word reading for the same level of performance due to its weaker processing pathways. However, both colour naming and word reading tasks were influenced by the allocation of attention and both were degraded when attention was reduced. Cohen, et al. (1990) noted that “…the fact that stronger pathways are controlled by attention is what allows the model to perform a task using the weaker of the two competing pathways” (p.350). The need for attention therefore varies with the strength of the underlying pathway but also with the requirements of the task. For example, colour naming required greater activation of the task demand unit to compete with a stronger process (i.e. word reading) than to compete with a weaker process (i.e. shape naming). “The stronger a process is, the less are its requirement for attention and the less susceptible it is to control by attention, increasing the likelihood that it will produce interference” (Cohen, et al., 1990 p.350). The model proposes that selective attention can be thought of as the mediating effect that the internal representation of context has on processing. “Attention can be viewed simply as an additional source of information that provides sustained context for the processing of signals within a particular pathway” (Cohen, et al., 1990, p.355).

Cohen and Servan-Schreiber (1992) implemented the model with degraded activity in the task demand units, representing specific deficits in context processing, and found an increase in overall response time with a disproportionate increase on colour naming incongruent trials; a pattern of effects that is typically found in schizophrenia with the card version of the Stroop task (e.g. Ngan & Liddle, 2000). Cohen and Servan-Schreiber (1992) note, however, that a disproportionate increase in Stroop interference in schizophrenia may
just as likely result from a general slowing of performance rather than a specific attentional
deficit (see Chapman & Chapman, 1978 for discussion of differential vs. generalised
deficit). Cohen and Servan-Schreiber (1992) ran the model again with a generalised
deficit, implemented by decreasing the rate at which information accumulates for units in
the network, which produced an overall slowing in responding but did not generate
disproportionate slowing in the interference condition. Slowing the process rate of units
throughout the network was therefore unable to account for schizophrenic performance in
the interference condition of the task.

Cohen and Servan-Schreiber (1992) simulated data suggest that a specific disturbance in
context processing, rather than a general slowing in processing, would account for the
pattern of schizophrenia Stroop data collected with card versions of the task. Barch, et al.
(2004) further argue that such a context processing deficit might also account for the
different pattern of schizophrenia Stroop data collected with the more sensitive single-trial
version of the task. If the ability to represent or maintain context representations (i.e.
respond to colour/word) is impaired then it would be expected that processing in the colour
naming pathway will be degraded, as it is the weaker process requiring greater attention,
but processing in the word reading pathway would be enhanced as it is the stronger process
requiring less attention (Barch, et al., 2004). Such a specific deficit could account for the
increase in reaction time Stroop facilitation without an increase in reaction time Stroop
interference (Barch et al., 2004; Burbridge & Barch, 2002; Barch, Carter, Hachten et al.,
1999; Barch, Carter, Perlstein et al., 1999; Carter et al., 1992; Carter et al., 1993; Carter et
al., 1997; Chen et al., 2001; Cohen et al., 1999; Henik et al., 2002; Taylor et al., 1996)
combined with an increase in error interference (Burbridge and Barch, 2002; Barch, Carter,
Hachten et al 1999; Barch, Carter, Perlstein et al 1999; Carter et al., 1997; Chen et al.,
2001; Cohen et. al., 1999) typically observed in schizophrenia with the single trial version
of the Stroop task. Barch, Carter and Cohen (2004) also recognise an alternative
hypothesis that context or task representations are intact in schizophrenia but that some
separate mechanism dedicated to inhibition is deficient (e.g Titone, Holzman & Levy,
2002). Such an inhibitory deficit may lead only to an increase in the influence of the word
dimension on performance resulting in increased reaction time facilitation and error
interference observed with the single trial version of the Stroop task. Both a context
processing deficit and an inhibitory deficit might therefore conceivably predict the pattern
of Stroop performance seen in groups with a diagnosis of schizophrenia.
To examine the independent contribution of colour naming and word reading in the performance of the Stroop task in a group with a diagnosis of schizophrenia Barch et al. (2004) used the process dissociation technique developed by Jacoby (1991). Process dissociation is obtained when an empirical manipulation changes the estimated contribution of one underlying process without affecting the other. Lindsey and Jacoby (1994) demonstrated that the estimated contribution of colour naming and word reading in Stroop stimuli can be independently manipulated. Increasing the frequency of congruent trials increased the estimated contribution of word reading but did not change the estimated contribution of colour naming. In contrast, degrading the quality of the colour dimension decreases colour naming but did not change word reading estimates. Estimated contributions of word reading and colour naming in the Stroop task can be derived using the following equations that are based on the probability of correct responses on congruent and incongruent trials (Jacoby, 1991; Lindsay & Jacoby, 1994):

\[
\text{Word reading estimate} = \text{Probability(Correct}\big|\text{Congruent}) - \text{Probability(Correct}\big|\text{incongruent})
\]

\[
\text{Colour naming estimate} = \frac{[\text{Probability(Correct}\big|\text{incongruent})]}{(1 - \text{Word reading estimate})}
\]

To generate sufficient variability in response accuracy required for the calculation of word reading and colour naming estimates Barch et al. (2004) used a speeded Stroop task designed to generate 80% overall response accuracy in a ‘normal’ non clinical sample. Participant instructions strongly emphasised response speed and participants’ response accuracy was subsequently recorded during each testing block. If accuracy was higher than 80% then participants were instructed to respond even quicker on the next testing block. If, however, response accuracy was below 80% they were instructed to slow their responding on the subsequent block. Barch et al. (2004) argued that if a selective attention deficit in schizophrenia were due to a deficit in inhibitory mechanisms then the estimated contribution of colour naming should be ‘normal’ or similar to that of the control group while the estimated contribution of word reading should be enhanced. However, if context processing is deficient in schizophrenia then they should display a decrease in the estimated contribution of colour naming and an increase in the estimated contribution of word reading. Consistent with a context processing deficit Barch et al. (2004) found that the group with a diagnosis of schizophrenia produced both a decrease in the estimated contribution of colour naming and an increase in the estimated contribution of word
reading. Furthermore, such a context processing deficit appears to be distinct from an inhibitory deficit typically associated with ageing. Spieler, Balota and Faust (1996), for example, using the same process dissociation techniques found that normal ageing adults had selective increases in word reading estimates without selective changes in colour naming estimate which is consistent with an inhibitory deficit rather than context processing deficit.

Barch et al. (2004) further analysed the relationship between colour naming estimates, word reading estimates and reaction times derived from the Stroop task. Higher colour naming estimates were associated with faster reaction times in the neutral condition for both the control group and the group with a diagnosis of schizophrenia. However, higher estimated contribution of word reading was associated with slower responses in the neutral condition only in the group with a diagnosis of schizophrenia. These findings are consistent with both a context processing deficit and a previous observation that selective attention deficits in schizophrenia lead to an increase in the influence of the word dimension in the neutral condition (Barch, Carter, Hachten et al., 1999) thereby leading to increase Stroop facilitation without a difference in Stroop interference.

There is evidence, however, that does not support predictions based on a context processing deficit. Cohen et al. (1999) suggested that Stroop experiments do not usually place strong demands on the maintenance of context due to trials being blocked by task (i.e. word reading or colour naming), so that the same instructions (context) are repeatedly reinforced. They suggested that reliance on context could be increased in the Stroop task by varying the task to be performed on each trial and by introducing a delay between the task instructions for each trial and the stimulus response. A test of these hypotheses, however, only partly corroborated their predictions. Predicted effects of delay were seen in patients diagnosed with schizophrenia as well as control group. They suggested that this might have been due to the manner in which the delay was manipulated in the task. The target stimulus followed the cue after a delay that alternated between 1 and 5 seconds. It was argued that this unpredictability may have disrupted the processing of context in the control group producing performance deficits similar to those seen in schizophrenia and reducing the ability to detect an effect of delay associated with schizophrenia. However, a similar study that delayed the cue instruction consistently, for 200, 500, 1000 and 2000ms, within blocks of stimuli and varied the task be performed on each trial (i.e. respond to colour or word) in one condition while consistently reinforcing the task to be performed in another condition also found no effect of delay or task variability in schizophrenia.
Another possibility is that the Stroop colour word task may be insensitive to numerous methodological manipulations. Reaction time tasks require sufficient data points to reduce within subjects response variability. However, increasing the number of trials also risks washing out between group’s effects as participants become practiced at the response level. Cohen et al. (1999) presented only 180 trials equally across three factor levels (i.e. congruence, delay and task type) while only using three colour responses (red, green and blue) that might resulted in rapid acquisition of the primary colour naming task.

The review thus far has highlighted the difficulty in drawing global conclusions about cognitive processes in schizophrenia with data collected from the Stroop task. Different methods of administration generate different patterns of data. Furthermore, the absence of increased interference does not necessarily indicate the absence of a cognitive deficit. A context processing deficit, in schizophrenia, that increases the relative influence of word reading and decreases the influence of colour naming, rather than a difficulty in inhibiting the word dimension of incongruent Stoop stimuli, seems to account for the pattern of Stroop data most consistently. There are however inconsistencies between theory and data in some studies (i.e. Cohen et al., 1999; Elvevag et al., 2000) that might reflect the inability of reaction time tasks to generate reliable data when numerous methodological manipulations are used. Effects may be present early in testing but unobservable due to large within subjects variability. However as the number of responses increases then the variability of responses decreases but effects may become unobservable due to increased practice.

**Stroop Performance in Multidimensional Schizophrenia/Schizotypy**

As briefly discussed above, the pattern of Stroop performance in schizophrenia differs depending on the symptom distinctions and comparisons made between them. Carter et al. (1993) classified subjects into ‘undifferentiated’ and ‘paranoid’ schizophrenia. Paranoid schizophrenia was defined by the presence of delusions or hallucinations but the absence of disorganised, affective or withdrawal symptoms. Undifferentiated schizophrenia was characterized by the presence of positive psychotic symptoms and disorganised symptoms while not meeting the criteria for paranoid, catatonic or disorganised subtypes. Carter et al. (1993) found no increase in reaction time interference (incongruent – control) and an increase in reaction time facilitation (congruent – control) present in ‘undifferentiated’
schizophrenia but the opposite pattern, that is, increased interference and decreased facilitation, in paranoid schizophrenia. This suggests that the dissociable components of the Stroop task (facilitation and interference) may tap the functioning of neural systems that are differentially affected in schizophrenic subtypes. Carter et al. (1993) concluded that the paranoid schizophrenia group display controlled attention or an inhibitory deficit in processing the irrelevant dimension of the Stroop stimuli while the undifferentiated groups inhibitory abilities are intact but mechanisms that produce automatic facilitation appear abnormal. However, both ‘undifferentiated’ and ‘paranoid’ schizophrenia include positive symptoms in their categorisation. This prevents accurate and meaningful interpretations regarding the association between cognitive functions and distinct schizophrenia symptoms. Carter et al. (1997) distinguished between positive, negative and disorganised symptom groups but found no association between patterns of results and the three subgroups measured. Others, also using the single trial version of the Stroop task, found that increased Stroop facilitation and error interference were associated only with the disorganised group (Barch, Carter, Hachten et al., 1999; Barch, Carter, Perlstein et al., 1999). However, these correlational analyses appeared somewhat exploratory and were not couched within a theoretical framework that enabled sound predictions.

The examination of Stroop effects and multidimensional schizotypy is more incomplete than that in schizophrenia. Studies specifically exploring Stroop performance in schizotypy are few. Given the hypothesised schizophrenia spectrum of disorders a similar pattern of Stroop performance would be expected in schizotypy. Effects may, however, be attenuated and therefore unobservable with a choice reaction time task. No studies, using various schizotypal measures, report increase interference (reaction time or error) or enhanced facilitation. Some studies have employed a unitary measure of schizotypy focusing on positive trait clusters/dimensions (Della Casa, Hofer, Weiner & Feldon, 1999; Beech, Baylis, Smithson & Claridge, 1989; Trestman et al., 1995; Suhr, 1997). One study made distinctions between positive and negative schizotypy (Dinn et al., 2002) while two have approached schizotypy as a multidimensional construct (Peters, Pickering & Hemsley, 1994; Steel, Hemsley & Jones, 1996). Most of these studies included the Stroop colour word task as part of a battery of measures exploring executive dysfunction. None specifically explore patterns of Stroop performance in schizotypy in the level of detail seen in the schizophrenia literature. These studies are therefore limited in the methodological detail required to make meaningful comparisons and interpretations. One possibility of a consistent failure to find Stroop performance associations with schizotypy is the use in several studies of a pattern mask (i.e. ######) after stimulus onset (Beech et al, 1989; Della
Casa et al., 1999; Peters et al., 1994; Steel et al., 1996). These studies report Stroop results obtained from a negative priming paradigm where stimulus backward masking is employed. Stimulus backward masking involves the presentation of a masking stimulus (e.g. ####) immediately after the presentation of the target stimulus. However, schizophrenia spectrum disorders are particularly susceptible to the disrupting effects of a pattern mask on target identification (e.g. Cadenhead et al., 1997). Most crucially, none of the studies have employed a single trial version of the Stroop task, which is thought to increase the task’s sensitivity (Carter et al., 1992) and remove the confounding influence of error responses.

2.2: Experiment 1. Stroop Colour Word Task

Previous studies have consistently failed to find Stroop task performance associations with schizotypy and they lack the methodological detail regarding the method of Stroop task administration thus preventing critical analyses. The Stroop colour word task might simply lack the sensitivity to detect cognitive deficits that are likely to be subtle in subclinical populations. Alternatively, the nature of executive deficits in negative schizotypy might be one of inhibition or context processing. Furthermore, these deficits might interact with various parameters of Stroop task administration in unexpected ways.

Stroop effects result from both colour naming and word reading processes (e.g. Barch, et al., 2004). Inhibitory deficits are expected to increase word reading processes only. This would slow reaction times to incongruent stimuli and increase reaction times to congruent stimuli but crucially, reaction times to neutral stimuli consisting of XXXX in various ink colours should remain unchanged. This would result in a larger Stroop interference effects (RT incongruent – RT neutral) and also larger Stroop facilitation effects (RT neutral – RT incongruent). In contrast, context processing deficits are expected to increase word reading processes but also decrease colour naming processes. This would slow reaction times to incongruent stimuli and neutral stimuli and increase reaction times to congruent stimuli. This should also produce a pattern of data characterized by increase interference effects and increased facilitation effects. Inhibitory or context processing deficits would therefore produce similar pattern of data. A decrease in colour naming is the critical difference between the two types of deficits. Selectively increasing attentional resources to colour naming but also decreasing attention resources to word reading should eliminate facilitation effects and leave only interference effects for interpreting the source of deficits.
Larger Stroop interference effects would subsequently indicate an inhibitory deficit while a smaller or comparable interference effect would indicate a context processing deficit. The logic on which these hypotheses are based will be outlined below.

Schizophrenia Stroop studies typically present a mixture of 50% neutral, 25% incongruent and 25% congruent trials. Such proportion means that half of all trials are neutral (i.e. XXXX) and require colour naming. This would result in a reduction in the amount of attentional resources that are allocated to colour naming (e.g. Tzelgov et al., 1992). The occurrence of congruent and incongruent trials would be relatively surprising as each of these trial types consist of only 1 in 4 of all trials. Due to the reductions in the amount of attentional resources allocated to colour naming, the infrequent occurrence of congruent and incongruent stimuli would result in an increase in the influence of the word dimension in processing both these types of dual dimensional colour word Stroop stimuli. This should produce slower responses to incongruent items compared to neutral items resulting in a significant interference effect and faster reactions to congruent items compared to neutral items resulting in a significant facilitation effect.

These particular manipulations of trial proportions essentially weaken context representations (‘respond to colour not word’) and are akin to reducing activity in colour naming units and increasing activity in word reading units in the task demand module of Cohen et al.’s (1990) connectionist model of the Stroop effect. The subsequent competition between a strong task irrelevant process (i.e. word reading) and weak task relevant process (i.e. colour naming) would result in a large Stroop interference effect. The compatibility between strong task irrelevant processes (i.e. word reading) and a weak task relevant process (i.e. colour naming) would result in a large Stroop facilitation effects. A deficit in the ability to use context representations (i.e. respond to colour not word) should increase these effects of trial proportion and enhance the influence of the task irrelevant process (i.e. word reading) and reduce the influence of the task relevant processes (i.e. colour naming). Such a context processing deficit should subsequently result in faster reaction times to congruent trials and slower reaction times to incongruent and neutral trials and generate a pattern of Stroop interference and facilitation that is indifferent from the pattern of effects expected from an inhibitory deficit.

Changing the proportions of trial types would enable the selective manipulation of colour naming and word reading processes. Tzelgov, Henik & Berger, (1992) for example, suggested that expectancy of the forthcoming trial can be manipulated by increasing or
decreasing the proportion of neutral trials. These expectations were thought to lead participants to modulate attentional resources. The greater the proportion of colour words (relative to neutral words), then the greater the amount of attentional resources allocated to colour naming.

Presenting an equal proportion of neutral, congruent and incongruent trials would therefore increase the amount of resources allocated to colour naming and also reduce the amount of attentional resources allocated to word reading. With such proportions, the majority of all trials (i.e. 66%) contain colour words and occur more frequently than neutral trials (i.e. XXXX) that do not contain a colour word dimension. The more frequent occurrence of colour word stimuli (congruent and incongruent) than neutral stimuli (XXXX) should therefore result in the strategic reduction in the amount of attentional resources allocated to word processing and a strategic increase in the amount of attentional resources allocated to colour naming. These proportions would essentially enhance the processing of context representations (i.e. respond to colour not word) and is akin to increasing activity in the colour naming unit and reducing activity in the word reading unit of Cohen et al. (1990) connectionist model. Essentially, presenting a greater proportion of colour word stimuli than neutral stimuli should strengthen context representations (i.e. respond to colour not word) that underpin successful performance on the Stroop colour word task.

**Predictions and Hypotheses**

Presenting a greater proportion of colour word trials than neutral trials should result in a weakening of dominant word reading processes and a strengthening of more passive but context relevant colour naming processes. Although reduced, word reading would remain dominant and interfere with strengthened (but still weak) task relevant colour naming processes on incongruent trials. However, such trial proportions that strengthen task relevant colour naming processes should disproportionately enhance reaction times to neutral stimuli. Stroop interference effects will therefore be larger than those typically produced with an equal proportion of colour word and neutral trials.

If these proportions have the intended effects on colour naming and word reading processes then they would also eliminate Stroop facilitation effects (**Hypotheses 1**). Increasing the allocation of attentional resources to colour naming would result in responses to neutral stimuli approaching the floor of human reaction time choice.
responses. The addition of a compatible word dimension on congruent trials would therefore not enhance reaction times beyond those from neutral trials.

With facilitation effects eliminated the interpretation of the nature of executive processing deficits in negative schizotypy would depend on the pattern of interference effects. Enhancements in colour naming and reductions in word reading would be expected to interact with a context processing and inhibitory deficits in different ways.

Firstly, if the executive processing abnormality in negative schizotypy were specifically characterised by a context processing deficit then individuals with many negative schizotypal traits would not benefit from the effects of trial proportions that strengthen weak but context relevant colour naming processes. The strengthening of weak context relevant colour naming processes would usually be expected to generate particularly large Stroop interference effect by disproportionately enhancing reactions to neutral trials. A context processing deficit should therefore produce a significantly smaller Stroop interference effect in a negative schizotypy group compared to a control group (Hypothesis 2). Furthermore, the reduction in the size of this Stroop interference effect should primarily result from significantly slower and less accurate responses to neutral stimuli in the negative schizotypy group compared to a control group (Hypothesis 3).

Secondly, if the executive processing abnormality in negative schizotypy were specifically characterised by an inhibitory deficit then individuals with many negative schizotypal traits would benefit from the effects of trial proportions that strengthen weak but context relevant colour naming processes. However, presenting a greater proportion of colour word trials than neutral trials would also weaken still dominant word reading processes. Therefore, if negative schizotypy were specifically characterised by an inhibitory deficit then individuals with many negative schizotypal traits would not benefit from the effect of trial proportions that weaken word reading processes that would otherwise enhance responses to incongruent stimuli. An inhibitory deficit would therefore produce a significantly larger Stroop interference effect in a negative schizotypy group compared to a control group (Hypothesis 4). Furthermore, the increase in the size of this Stroop interference should result from significantly slower and less accurate responses to incongruent stimuli in the negative schizotypy group compared to a control group (Hypotheses 5).
2.2.1: Experiment 1. Method

Introduction

Experiment 1 examined performance of high and low introvertive anhedonia groups, the O-LIFE negative schizotypy dimension, on a modified Stroop task that manipulated the relative proportions of congruent, incongruent and neutral trials. It addresses three specific hypotheses that intended to differentiate between an inhibitory and a context processing account of the executive deficits in negative schizotypy. To maximise the Stroop task’s sensitivity, a single trial version of the task was used (e.g. Barch, Carter, Hachten et al., 1999). Further, to remove possible effects of practice while still providing sufficient data points to produce small within subject variability, the task was presented in two testing sessions separated by a number of other reaction time tasks. The configuration of the task was also intended to remove the possible confound of negative priming between items. Negative priming is the observation of an increase in reaction time when the irrelevant word on trial n is the same as the ink colour on trial n +1 (Tipper & Cranston, 1985). There is some evidence that negative priming may be reduced in schizotypy (Moritz & Mass, 1997; Moritz, Mass & Jung, 1998).

A pseudorandom trial presentation order was therefore utilised, rather than fully randomised, to ensure that no negative priming occurred between trials. To account for proportion effects an equal number of congruent, incongruent and neutral trials were also used rather than the more common 2:1:1 neural, incongruent, congruent ratio (e.g. Barch, Carter, Hachten et al., 1999). Three colour words are typically used in the Stroop colour word task (e.g. Barch, Carter, Hachten et al., 1999), which results in incongruent trials having only two possible response options. For example, if the colour word ‘RED’ is presented then its print colour will be one of two other colours that form the response set. The current experiment therefore used four colours so that each incongruent trial would have three possible response options. This was intended to increase the overall difficulty of the task with the aim of increasing its sensitivity at detecting subtle cognitive deficits between high and low scoring introvertive anhedonia groups.
Participants

Forty six participants were recruited into the study 83% of who were female. The mean age was 22.5 years with a standard deviation of 6.1. Participants were invited to participate on the bases of their O-LIFE introvertive anhedonia subscale scores, which had been collected at a number of data collection sessions in the previous two years. To account for age and gender differences in levels of introvertive anhedonia the allocation to low and high introvertive anhedonia groups was based on normed introvertive anhedonia scores equal to or less than the 25th percentile and scores equal to or greater than the 75th percentile of a normed introvertive anhedonia distribution (Mason & Claridge, 2006; see Table 5). Exclusion criteria included known colour blindness, non-corrected vision less than 20/20 and being under the influence of substances known to distort mood, perception and or attention. The demographics of the high and low introvertive anhedonia groups was not known until the end of data collection and are therefore reported in the results section.

Materials

The Stroop task was programmed and presented using e-prime v.1.2 application suite. It used the words and colours red, green, blue and yellow. Forty eight trials were constructed divided equally across practice, neutral congruent and incongruent conditions. The 12 practice items were four #'s (#####) presented in each of the four colours three times (e.g. #### in green ink). Similarly, the 12 neutral items were four X’s presented in each of the four colours three times (e.g. XXXX in yellow ink). The 12 congruent items consisted of each colour word presented in its own colour three times (e.g. RED in red ink) while the 12 incongruent items consisted of each of the colour words presented in each of the other colours once (e.g. RED in blue ink). The 36 congruent, incongruent and neutral trials were divided equally across three blocks ensuring no within block repeats.

Procedure

The experimenter observed and supervised the completion of practice trials to ensure that the demands of the task had been understood. Participants subsequently completed critical trials alone in an experimental testing booth. They were asked to sit at a comfortable distance, approximately 1 meter, from the computer screen. A fixation point (+) was
presented at the centre of a blank screen and participants were asked to ensure that it was horizontal with their eye level. The chair or, in extreme cases, the monitor could be adjusted to ensure that this criterion was met. Two instruction pages were then presented which introduced and presented the requirements of the task. These instructions were also relayed to the participants verbally. They were asked to respond to the colour of the print in which each stimulus was presented by pushing the corresponding button on the serial response box. An equal emphasis was placed on response speed and accuracy. Participants initiated the experiment by pushing the centre button on the response box. Each trial began with a fixation point (+) presented for 500ms. This was immediately replaced (i.e. one refresh rate of the monitor) by the critical stimulus, which was presented until a response was made or until 2000ms elapsed at which point a 'no response' was recorded. At its offset, a further fixation point (+) was displayed for 1500ms. Continuous presentations of trials therefore provided a consistent inter trial interval of 2000ms and a maximum trial length of 4000ms.

Stimuli were presented in 4 blocks. A short break followed each block, which participants ended and continued with the task by pushing the response box centre button. The first block contained practice items to which the participants had to achieve 80% response accuracy. The practice block was repeated until this criterion was met. The remaining 3 blocks contained the 36 critical trials. Within block item presentation was fixed in a pseudorandom order ensuring that the colour of the print on any current trial was different to the word on the previous trial. This rule was also applied to the item at the beginning and end of each block to ensure no priming effects between blocks regardless of block presentation order. While within block item presentation was fixed, block presentation was randomised across participants and two testing sessions.

The experimenter observed and supervised completion of the practice block to ensure that participants understood the demands of the task. Each participant completed the Stroop task twice as part of a larger study. At the first session, the task was novel while the second session occurred immediately after the participant had completed an emotional Stroop task (experiment 3 of the current thesis), which lasted for approximately 2 minutes, and a dot probe task (experiment 4 of the current thesis), which lasted for approximately 8 minute. Following testing participants were given a full de-brief.
Method of Analyses

The first set of analyses intended to account for the possible confounding influence of other schizotypal trait dimensions on the dependent measure of interest. Reaction times and errors were analysed, as both are equally valid dependent measures of the Stroop effect.

Multiple Regression analyses were first conducted with a reaction time measure of Stroop interference (RT incongruent minus RT neutral) as the dependant variable and unusual experiences, impulsive non-conformity and cognitive disorganisation schizotypy dimensions as predictors. Data were screened for outliers, which if present were removed from the analyses. Furthermore, normality of the data was assessed and if significant skew were present then the particular variable was transformed until normality was achieved.

The error measure of Stroop interference (proportion of errors to incongruent minus proportion of errors to neutral) did not meet the testing assumptions for regression analyses. The distribution was skewed and could not be normalised by transformations. The distribution was also leptokurtic as most observations were around zero. The error measure of Stroop interference was therefore transformed into a nominal variable consisting of a Stroop effect category and a no Stroop effects category. The Stroop effect category was defined by participants who generated a greater proportion of errors whilst responding to incongruent trials than neutral trials. The no Stroop effect category was defined by participants who generated the same proportion of errors responding to incongruent and neutral items or a greater proportion of errors responding to neutral than incongruent stimuli. This dichotomised measure of Stroop interference was then analysed as the dependent variables in a logistic regression that included unusual experiences, impulsive non-conformity and cognitive disorganisation schizotypy dimensions as predictors.

The second set of analyses examined the reaction times and error percentages of the high and low scoring introvertive anhedonia groups and were conducted using ANOVA. Reaction times and errors were again analysed, as both are equally valid dependent measures of the Stroop effect. These analyses were conducted and presented consecutively and examined Stroop interference (incongruent minus neutral) and Stroop facilitation (neutral minus congruent) effects using 2x (Stroop condition) by 2x (introvertive anhedonia group: high/low) mixed ANOVA’s. Planned comparisons were examined using independent and repeated measures t-tests.
2.2.2: Experiment 1. Results

Demographics

One participant was excluded from all analyses as they produced outlying reaction times in two of the experimental conditions. In accord with the criteria outlined in the method section, 27 of the remaining 46 participants were defined as low introvertive anhedonia and 19 defined as high. Mean ages and gender composition of the high and low introvertive anhedonia groups are presented in Table 7. Being defined as high or low introvertive anhedonia was not associated with gender (p<.05 fishers exact test). Furthermore, the high and low introvertive anhedonia group did not have statistically different ages (t=0.200, df = 44, p>.05).

<table>
<thead>
<tr>
<th>Gender</th>
<th>Low (n=27)</th>
<th>High (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>22</td>
<td>16</td>
</tr>
<tr>
<td>Male</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Age (mean/SD)</td>
<td>22.4 (5.5)</td>
<td>23.7 (7.0)</td>
</tr>
</tbody>
</table>

Table 8 below displays the O-LIFE total score and subscale scores of the high and low introvertive anhedonia groups. The high introvertive anhedonia group had higher mean unusual experiences, cognitive disorganisation and impulsive non-conformity scores than the low group. These group differences were not statistically significant for the impulsive non-conformity (t=0.991, df=27.231, p>.05) subscale scores. However, the high introvertive anhedonia group did have significantly higher unusual experiences (t=2.330, df=44, p<.05) and cognitive disorganisation (t=2.071, df=44, p<.05) subscale scores (see Table 8).
Table 8
O-LIFE total scores and subscale scores by high/low introvertive anhedonia

<table>
<thead>
<tr>
<th></th>
<th>Low (n=27)</th>
<th>High (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Unusual Experiences</td>
<td>8.11 (5.94)</td>
<td>12.74 (7.51)</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>12.15 (4.24)</td>
<td>15.21 (5.80)</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>8.78 (2.78)</td>
<td>9.95 (4.58)</td>
</tr>
<tr>
<td><strong>Introvertive anhedonia</strong></td>
<td><strong>1.30 (0.78)</strong></td>
<td><strong>11.47 (3.27)</strong></td>
</tr>
<tr>
<td>O-LIFE Total</td>
<td>30.33 (8.36)</td>
<td>49.37 (14.57)</td>
</tr>
</tbody>
</table>

Stroop Experimental Analyses

Erroneous responses, consisting of 3.50% of the data set, were removed from the analyses. Short and long extreme reaction times constituted a further 0.82% of the data set and were also removed. With consideration given to the recommendations by Ratcliff (1994) extreme responses were defined in the current study as participant’s reaction times greater than 3 standard deviations from their individual means and all reaction times less than 200ms. Conservative cut offs were selected to minimise the number of data points lost by trimming while still removing the potential effects of outliers. Reaction times greater than 3 standard deviations from individuals’ mean reaction times are at the extremes of individual reaction time distributions and might represent interruptions to cognitive processes from internal or external sources. Furthermore, given that 200ms is near the floor of human reaction time responses (e.g. Lamming, 1968) any reaction times shorter than these might reflect anticipatory responding.

Multiple Regression Analyses

The regression analyses examined Stroop reaction time interference (incongruent minus neutral) as the dependant variable with schizotypy trait dimensions that were not of direct relevance to the current investigation as predictor variables. The dependant variable (Stroop interference) and the unusual experiences variable had significant skew and were subjected to square root transformation. All other variables were normally distributed. The unusual experiences, impulsive non-conformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method. A significant model emerged (F(3,42)=3.873, p=.016) which explained 16.1% of the variance of the Stroop interference reaction time measure (Adjusted R² = .161). However, none of
the included schizotypal dimensions were significant predictors of Stroop interference (see table 9).

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>-0.83</td>
<td>0.50</td>
<td>-0.27</td>
<td>.106</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>-0.22</td>
<td>0.16</td>
<td>-0.22</td>
<td>.139</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-0.11</td>
<td>0.11</td>
<td>-0.15</td>
<td>.339</td>
</tr>
</tbody>
</table>

**Logistic Regression Analyses**

A logistic regression analysis was conducted with a dichotomised measure of error Stroop interference effect (no Stroop effect category: no difference in error between incongruent and neutral stimuli or greater proportion of errors to neutral than incongruent stimuli vs. Stroop effect category: greater proportion of errors to incongruent than neutral stimuli) as the dependent variable and unusual experiences, impulsive nonconformity and cognitive disorganisation as predictor variables. A total of 46 cases were analysed but a significant model did not emerge (omnibus chi-square = 0.807 df = 3, p>.05) indicating that none of the included schizotypal dimensions predicted the occurrence of an error Stroop interference effect (see appendix 1. table A1.1 for coefficients of predictors)

**ANOVA of Reaction Times**

Mean reaction times to the congruent, incongruent and neutral Stoop conditions for the low and high introvertive anhedonia groups are presented in table 10. Both the high and low introvertive anhedonia groups generated a small facilitation effect. Mean reaction times were marginally faster to congruent than neutral stimuli. A Stroop interference effect was also evident in both groups. The high and low introvertive anhedonia groups mean reaction times slower to incongruent than neutral stimuli. The size of this effect was
however larger for the low (118ms) than the high (77ms) introvertive anhedonia group (see figure 3 below).

Table 10
Reaction time means in milliseconds and standard error (SE) of the high and low introvertive anhedonia groups for the incongruent, neutral and congruent Stroop conditions

<table>
<thead>
<tr>
<th></th>
<th>Low n = 27</th>
<th>High n = 19</th>
<th>Total n = 46</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SE)</td>
<td>Mean (SE)</td>
<td>Mean (SE)</td>
</tr>
<tr>
<td>Congruent</td>
<td>676 (23)</td>
<td>684 (27)</td>
<td>679 (18)</td>
</tr>
<tr>
<td>Neutral</td>
<td>678 (23)</td>
<td>693 (22)</td>
<td>684 (16)</td>
</tr>
<tr>
<td>Incongruent</td>
<td>796 (21)</td>
<td>770 (27)</td>
<td>785 (16)</td>
</tr>
</tbody>
</table>

The first ANOVA examined facilitation effects (mean neutral – mean congruent). Mean reaction times of the high and low introvertive anhedonia groups from the neutral and congruent Stroop conditions were entered into a two way condition (neutral vs. congruent) by introvertive anhedonia group (high vs. low) mixed ANOVA. The analyses revealed no main effect of Stroop condition (F(1,44)=0.825, p>.05), indicating the absence of a Stroop facilitation effect. The analyses also revealed no main effect of introvertive anhedonia group (F(1,45)=0.118, p>.05), indicating that global mean reaction times for the high (M=680, SE=22) and low (M=689, SE=26) introvertive anhedonia groups did not significantly differ. The analyses also revealed no Stroop condition by introvertive anhedonia group interaction (F(1,44)=0.245, p>.05), indicating that Stroop facilitation effects (mean neutral – mean congruent) did not significantly differ for the high (M=9, SE=9) and low (M=2, SE=8) introvertive anhedonia groups.

The second ANOVA examined interference effects (mean incongruent – mean natural). Mean reaction times from the neutral and incongruent Stroop conditions of the high and low introvertive anhedonia groups were entered into a two-way 2x condition (neutral vs. incongruent) by 2x introvertive anhedonia group (high vs. low) mixed ANOVA. The analyses revealed a main effect of Stroop condition (F(1,44)=98.170, p<.001, η²=.691). This indicated the presence of a Stroop interference effect as reaction times were on average slower to incongruent trials (M=783, SE=17, CI,95 = 750, 817) than neutral trials (M=686, SE=16, CI,95 = 653, 719). The ANOVA analyses found no main effect of introvertive anhedonia group (F(1,45)=0.030, p>.05), indicating that global mean reaction
times did not significantly differ between the high (M=732, SE=24) and low (M=737, SE=20) introvertive anhedonia groups. However, the analyses did reveal a significant Stroop condition by introvertive anhedonia group interaction (F(1,44)=4.218, p<.05, partial $\eta^2=.087$) (Figure 3), indicating that the magnitude of the Stroop interference effect (mean incongruent – mean natural) (figure 3) was significantly larger for the low (M=118, SE=13, $CI_{95} = 92, 143$) than the high (M=77, SE=15, $CI_{95} = 46, 107$) introvertive anhedonia group.

![Figure 3. Stroop interference for the low and high introvertive anhedonia groups (error bars represent SE of the mean). Note: Stroop interference effects are differences between reaction times on incongruent trials and neutral trials.](image)

An independent samples t-test comparing the Stroop interference effect (mean incongruent – mean natural) between the high and low introvertive anhedonia groups confirmed the results of the ANOVA. The low introvertive anhedonia group produced a significantly larger Stroop interference effect than the high introvertive anhedonia group ($t=2.054$, $df=44$, $p<.05$) (figure 3). Further, planned comparison examining source of the between groups difference in Stroop interference found that the high and low introvertive anhedonia groups did not have significantly different reaction time means to neutral trials ($t=0.448$, $df=44$, $p>.05$, one tailed) or incongruent trials ($t=0.445$, $df=44$, $p>.05$) (see table 10 above).
ANOVA of Errors

Participants mean percent of errors from responses to congruent, incongruent and neutral Stroop conditions are presented in Table 11 below. Both the high and low introvertive anhedonia groups produced a greater proportion of errors whilst responding to neutral than congruent items thus displaying a Stroop facilitation error effect. Furthermore, both the high and low introvertive anhedonia groups produced a greater proportion of errors whilst responding to incongruent than neutral Stroop stimuli thus displaying a Stroop interference error effect.

Table 11.
Mean error percentage and standard error of the high and low introvertive anhedonia groups for the incongruent, neutral and congruent Stroop conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Low n = 27 Mean (SE)</th>
<th>High n = 19 Mean (SE)</th>
<th>Total n = 46 Mean (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congruent</td>
<td>2.16 (0.52)</td>
<td>2.41 (0.80)</td>
<td>2.26 (0.44)</td>
</tr>
<tr>
<td>Neutral</td>
<td>2.31 (0.60)</td>
<td>3.95 (1.44)</td>
<td>2.99 (0.69)</td>
</tr>
<tr>
<td>Incongruent</td>
<td>5.25 (1.25)</td>
<td>6.80 (2.28)</td>
<td>5.89 (1.18)</td>
</tr>
</tbody>
</table>

The first ANOVA examined error facilitation effects (mean error neutral – mean error congruent). Mean percentage of errors from the neutral and congruent Stroop conditions of the high and low introvertive anhedonia groups were entered into a two-way 2x condition (neutral vs. congruent) by 2x introvertive anhedonia group (high vs. low) mixed ANOVA.

The analyses revealed no main effect of Stroop condition (F(1,44)=1.273, p>.05), indicating the absence of a Stroop error facilitation effect. The analyses also revealed no main effect of introvertive anhedonia group (F(1,45)=1.061, p>.05), indicating that global mean errors for the high (M=3.18, SE=0.70) and low (M=2.24, SE=0.59) introvertive anhedonia groups did not significantly differ. The analyses also revealed no Stroop condition by introvertive anhedonia group interaction (F(1,44)=0.850, p>.05), indicating that Stroop error facilitation effects (mean error neutral – mean error congruent) did not significantly different for the high (M=1.54, SE=1.15) and low (M=0.15, SE=0.96) introvertive anhedonia groups.
The second ANOVA examined error interference effects (mean error incongruent – mean error natural). The mean percentage of errors from the neutral and incongruent Stroop conditions of the high and low introvertive anhedonia groups were entered into a two-way 2x condition (neutral vs. incongruent) by 2x introvertive anhedonia group (high vs. low) mixed ANOVA.

The analyses revealed a main effect of Stroop condition (F(1,44)=5.379, p<.02, η²=.109, one tailed). This indicated the presence of a Stroop error interference effect. There were, on average, a significantly greater percentage of errors to incongruent trials (M=6.00, SE=1.2, CI95=3.60, 8.50) than neutral trials (M=3.10, SE=0.70, CI95=1.70, 4.50). The ANOVA analyses also revealed no main effect of introvertive anhedonia group (F(1,44)=1.074, p>.05), indicating that global mean reaction times did not significantly differ between the high (M=5.37, SE=1.18) and low (M=3.78, SE=0.99) introvertive anhedonia groups. The analyses further revealed no Stroop condition by introvertive anhedonia group interaction (F(1,44)=0.001, p>.05), indicating that Stroop error interference effects (mean error neutral – mean error congruent) did not significantly differ for the high (M=2.93, SE=1.60) and low (M=2.85, SE=1.91) introvertive anhedonia groups.

2.2.3: Experiment 1. Discussion

Summary of Findings

In summary, the experiment did not generate facilitation effects. Reaction times to congruent stimuli were not significantly faster than those to neutral stimuli and the proportion of errors were not significantly smaller for congruent than neutral stimuli. Furthermore, these results did not differ for the high and low introvertive anhedonia groups as neither group produced a reaction time or error facilitation effect.

Stroop interference effects were, however, observed in both the reaction time and error data. Reaction times were significantly slower to incongruent stimuli than neutral stimuli and there were significantly greater percentage of errors to incongruent than neutral trials. Between groups Stroop interference effects were also observed in the reaction time data. The high introvertive anhedonia group produced a significantly smaller Stroop interference effect (mean RT incongruent – mean RT neutral) than the low introvertive anhedonia...
group. However, the source of this between groups effect was uncertain, as reaction times of the high and low introvertive anhedonia groups did not significantly differ to incongruent or neutral trials. Similar between groups Stroop interference effects were not observed in the error data as both the high and low introvertive anhedonia groups generated comparable sized Stroop error interference effects that were characterised by significantly greater proportion of errors to incongruent than neutral trials.

**Comment on Findings**

The absence of a Stroop facilitation effects (neutral response – congruent response) is consistent with hypothesis 1 and suggests that manipulations of trial proportion had the intended effect on colour naming and word reading processes. It was hypothesised that presenting a greater proportion of colour word trials than neutral trials would weaken dominant word reading processes and strengthen more passive but context relevant colour naming processes. Word reading would remain dominant over still weak task relevant colour naming processes. However, the strengthening of task relevant colour naming processes was expected to disproportionately enhance reactions to neutral trials than congruent trials as responses approach the floor of human reaction time choice responses. The addition of a compatible word dimension on congruent trials was not expected to enhance reactions beyond those from neutral trials thereby eliminating Stroop facilitation effects.

Neither the high nor low introvertive anhedonia group produced a Stroop facilitation effect suggesting that both groups benefited from the manipulations of trial proportion. The enhancement of colour naming processes presumably enabled both groups to reach their floor choice response to neutral trials and the addition of a compatible word dimension on congruent trials did not enhance responses further. With facilitation effects removed, the interpretation of executive processing deficits in introvertive anhedonia would be dependent on the pattern of interference effects. A deficit in context processing was expected to result in a significantly smaller Stroop interference effect (Hypotheses 2) that was primarily driven by slower and less accurate responses to neutral trials (Hypotheses 3). However, an inhibitory deficit was expected to result in significantly larger Stroop interference effect (Hypotheses 4) that was driven by slower and less accurate responses to incongruent trials (Hypotheses 5).
The high introvertive anhedonia group produced a significantly smaller Stroop interference effect than low introvertive anhedonia group. These results are consistent with hypothesis 2 and suggest that the executive processing abnormality in introvertive anhedonia is characterised by a deficit in processing contextual representations. Presenting a greater proportion of colour word trials than neutral trials was expected to enhance representations of context (‘respond to colour not word’) and strengthen colour naming processes so that responses to neutral trials were disproportionately enhanced thus resulting in a particularly large Stroop interference effect. A deficit in processing contextual representations was expected to result in an inability to benefit or make use of majority colour word trial proportions to enhance context relevant colour naming processes thereby producing a smaller Stroop interference effect. However, despite the high introvertive anhedonia group producing a significantly smaller Stroop interference effect than the low group, the source of this difference was not driven by group differences on neutral trials. Hypothesis 3 was therefore not supported, as the low introvertive anhedonia group did not generate significantly faster reaction times to neutral trials than the high introvertive anhedonia. It seems that responses to both neutral trials and incongruent trials contributed to the smaller Stroop interference effect observed in the high introvertive anhedonia group.

The competing hypothesis 4, that predicted an inhibitory deficit in introvertive anhedonia would result in a larger Stroop interference effect, was also not supported. Hypotheses 5, which further predicted that such an affect would be driven by slower responses to incongruent stimuli, was also not supported.

The results of the high introvertive anhedonia group are therefore consistent with a context processing deficit and not with an inhibitory deficit. Changing the proportion of neutral, congruent and incongruent trials was argued to change macro level resource allocation. In the current experiment, a majority of colour word trials seems to have resulted in a greater amount of resource allocation to colour naming and therefore an enhancement of context processing representations (‘respond to colour not word’). Such manipulations were expected to eliminate facilitation effects and produce large Stroop interference effects. However, unlike the low introvertive anhedonia group, the high introvertive anhedonia group were unable to make use of macro level adjustment in resource allocation to enhance context representations and therefore generated a smaller Stroop interference effect.

To summarise, despite a significantly smaller Stroop interference effect of the high introvertive anhedonia group supporting a conclusion based on a context processing
deficit, the source of the effect was unclear. It was expected that a context processing
deficit with the current trial proportions would produce comparable responses to
incongruent stimuli but significantly slower and less accurate responses to neutral stimuli.
However, the high and low introvertive anhedonia groups produced comparable responses
to both incongruent and neutral stimuli. This suggests that non-significant group
difference to neutral trials and incongruent trials contributed to the significant group
difference in Stroop interference. A smaller Stroop interference effect would therefore
result from slower responses to neutral stimuli and faster responses to incongruent stimuli.
Such a pattern of data might result from a deficit in context processing and enhancements
in inhibitory control operating simultaneously. A deficit in context processing might result
in non enhanced reactions to neutral stimuli while enhancements in inhibitory control
would result in enhanced reactions to incongruent stimuli. However, such effects do not
seem to be observable with the current experimental parameters. Experiment 2 will
address such shortcomings by providing micro level or trial-by-trial measures of both
inhibition and context processing.

Methodological Problems and Limitations of the Study

The most apparent methodological confound of the current study is that the high
introvertive anhedonia group was not only significantly higher than the low group on
levels of introvertive anhedonia but also on levels of unusual experiences and cognitive
disorganisation, the O-LIFE’s measure of positive schizotypy and disorganisation.
Observed effects between the high and low introvertive anhedonia groups cannot therefore
be attributed solely to levels of the negative schizotypy but to globally higher levels of
schizotypy.

The multiple regression analyses provide support for these conclusions. Although none of
the other schizotypal trait dimensions significantly predicted Stroop interference, an
overall significant model suggests that global schizotypy scores do contribute to smaller
Stroop effects.

Its worth noting however that the median unusual experiences score for the high
introvertive anhedonia group in the current was 13 with an interquartile range between 5
and 17, which are all within the third quartile of the normed unusual experiences
distribution (see Table 5). This suggests that the majority of the high introvertive
anhedonia group are defined, according to the criteria used in the current study, as having a medium number of unusual experiences traits. Similarly, the median unusual experiences score for the low introvertive anhedonia group in the current experiment was 5 with an interquartile range between 4 and 11, which are within the second quartile of the normed distribution (see Table 5). This again suggests, according to the criteria used in the current study, that the majority of the low introvertive anhedonia group had a medium number of unusual experiences traits. Therefore, despite the high introvertive anhedonia group having significantly higher levels of unusual experiences than the low introvertive anhedonia group, the majority of both groups had unusual experiences scores that were in the middle of the normed distribution. The high introvertive anhedonia group, in the current study, therefore have a high number of introvertive anhedonic traits but a medium number of unusual experiences traits while the low introvertive anhedonia group have a low number of introvertive anhedonic traits but also a medium number unusual experiences traits. This suggests that the current experiment was somewhat successful in recruiting individuals who were atypically high or low on negative schizotypy but had a medium number of positive schizotypal traits. Similar analyses and conclusions can also be made for the cognitive disorganisation subscale. According to the criteria used in the current study, the majority of the high and low introvertive anhedonia groups had medium levels of cognitive disorganisation.

**Future Research**

A context processing account of the data pattern from the current experiment suggests that global, or macro level, adjustment in resource allocation occurred from manipulating the proportion of neutral trials (i.e. XXXX) to colour word trials. However, hypotheses were only partially supported as detailed analyses failed to confirm predictions supporting a context processing or an inhibition account of the executive deficits in negative schizotypy. Experiment 2 will attempt to address these shortcomings by manipulating the strength of context representations trial-by-trial to measure micro level adjustments in resource allocation that occur either within a trial or between trials (e.g. Ridderinkhof, 2002).

Responding to incongruent stimuli in the Stroop colour word task requires a regulative cognitive control function in order to increase colour naming and override the prepotency of word reading. However, an evaluative process must also be active in detecting the conflict generated by colour word incongruence and subsequently signalling the
requirement for increased cognitive control. The anterior cingulate cortex (ACC) is thought to be involved in this evaluative process by monitoring competition between conflicting processes (Botvininck, Cohen & Carter, 2004) and subsequently signalling the need for additional executive control to the prefrontal cortex (PFC) (Kerns et al., 2004). The conflict detected on an incongruent trial might therefore signal the requirement for control, which is then implemented through the enhancement of context representations (i.e. respond to colour not word). Evidence for such a process has been observed using the Erikson flanker task. Gratton, Coles and Donchin (1992) found that the distracting effect of the flanker was weaker on trials that followed incongruent trials (iI trial) than on trials that followed congruent ones (cI trials). If high scoring introvertive anhedonics are associated with a context processing deficit then they should be unable to make use of conflict detection signals to enhance context representations and therefore be unable to behaviourally adjust performance trial-by-trial.

The examination of micro level, or trial-by-trial, behavioural adjustment to conflict will be addressed in experiment 2. The experiment will attempt to find supporting evidence for a context processing deficit in high introvertive anhedonia that is dissociated from a deficit in inhibition. Reaction times typically decrease to incongruent stimuli that immediately follow other incongruent stimuli (iI trials), which are thought to indicate behavioural adjustment to the detection of conflict (see Kerns et al., 2004 for detail). Experiment 2 will therefore generate high conflict incongruent Stroop colour word trials by experimentally manipulating the allocation of resources to colour naming and word reading. It will then examine subsequent trial-by-trial behavioural adjustments of high and low scoring introvertive anhedonic groups to these high conflict trials.

Conclusions

Presenting a greater proportion of colour word stimuli than neutral stimuli was argued to increase resource allocation to colour naming thereby enhancing context representations (i.e. respond to colour not word) that would result in disproportionately enhanced reaction to neutral trials than incongruent trials leading to particularity large Stroop interference effects. The high introvertive anhedonia group generated a significantly smaller Stroop interference effect than the low group, which suggests that they have a deficit in context processing as they were unaffected by the manipulations of trial proportions. This suggests
that the high introvertive anhedonia groups were unable to make use of macro level adjustment in resource allocation to enhance task relevant context representations.

Predictions were, however, only partially supported. Deficit in context processing induced reductions in the size of Stroop interference in the high introvertive anhedonia group were expected to result from slower and less accurate responses to neutral trials. The high and low introvertive anhedonia group did not produce significantly different reactions to either neutral or incongruent trials. This suggested that responses to both types of trials resulted in observed effects and the processing of context and inhibition might both have contributed. Experiment 2 will address this by measuring both context processing and inhibitory processes through micro level or trial-by-trial adjustments in resource allocation.

A further limitation of the study suggests that smaller Stroop interference effects are not unique to negative schizotypy and that global schizotypy scores contribute to smaller Stroop interference. Conclusions are therefore tentative as the effects of processing context and inhibitory processes could not be fully separated and effects of interests were not isolated to negative schizotypal traits.

### 2.3. Experiment 2. Stroop Conflict Adjust

Experiment 2 will attempted to find supporting evidence for a context processing deficit in high introvertive anhedonia and dissociate this from an inhibitory deficit by examining micro level, or trial-by-trial, adjustment in resources allocated to colour naming and word reading. It specifically attempted to increase the size of the Stroop interference effect by biasing participant’s processing pathways through block presentation of congruent Stroop items followed by immediate block presentation of incongruent Stroop items. The experiment explored the possibility that mechanisms detecting and signalling the requirement for increased cognitive control differ between high and low introvertive anhedonia groups. The configuration of experiment 2 and justification for such a method will be discussed further detail below.

Cognitive control (or executive processing) is required for the human cognitive systems to perform different tasks through appropriate adjustments in perceptual selection, response biasing and the on-line maintenance of contextual information. The dorsolateral prefrontal cortex (DLPFC) is thought to be involved in cognitive control in a regulative manner by
representing and maintaining attentional demands of a task (Miller & Cohen (2001) or, in
the words of Cohen & Servan-Schreiber (1992), the internal representation of context is
“information held in mind in such a form that it can be used to mediate an appropriate
behavioural response” (Cohen & Servan-Schreiber, 1992, p.46). In addition to this
regulative control function there must also exist an evaluative component that monitors
information processing and assesses the need for control. For example, in the Stroop
colour word task cognitive control is required while responding to incongruent trials in
order to override the prepotent response of word reading. An evaluative process must,
however, also be active in detecting the colour word incongruence and signalling the
requirement for control.

The amount of conflict occurring on any particular trial is related to the amount of trial-by
trial adjustment of control, which Ridderinkhof (2002) referred to as micro adjustment.
For example, Gratton et al. (1992), found that the distracting effect of the flanker, in the
Erikson flanker task, was weaker on trials that followed incongruent trials (iI trials) than on
trials that followed congruent ones (cI trials). Kerns et al. (2004) replicated the effect
using the Stroop colour word task to account for the suggestion that post conflict
behavioural adjustment observed with the flanker task was due to the effects of stimulus
repetition. Mayr, Awh and Laurey (2003) suggested that the apparent behavioural
adjustment to conflict observed in studies using the flanker task could have been due to
stimulus specific repetition priming. That is, 50% of congruent-congruent (cC) trials and
incongruent-incongruent (iI) trials will present the same target and flanker on trial n and
trial n+1. Mayr et al. (2003) found that a conflict adaptation effect was only present for
trials where target and flanker were repeated (but see Ullsperger, et al., 2005 for conflict
adaptation effect without flanker-target repeats). However, the Stroop task has a greater
number of response options than the flanker task. Kerns et al. (2004), therefore, only
analysed trials that did not include a repetition of colour or word and found a behavioural
conflict adaptation effect. Reaction times were significantly faster on incongruent trials
that were preceded by incongruent trials (iI) than reaction times on incongruent trials
preceded by congruent trials (cI). The occurrence of an incongruent trial seems to lead to
increase control over the response conflict on the subsequent incongruent trial. Cognitive
control is therefore engaged after a conflicting trial (i.e. an incongruent trial) but relaxed
after a non-conflict trial (i.e. a congruent trial).

This conflict adaptation effect has been observed in numerous studies using different
congruency tasks (Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999; Egner & Hirsch,
The occurrence of incongruence is thought to signal the requirement for control (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Carter et al., 2000; Kerns et al., 2004), which leads to the enhancement of context processing representations (Botvinick et al., 2001; Miller and Cohen, 2001) and greater cognitive control over the response conflict of subsequently presented incongruent trials.

Experiment 2 aimed to measure inhibition and context processing in the high and low introvertive anhedonia groups. It aimed to reducing strategic processes and increasing conflict through methodological manipulations similar to those reviewed in the previous section. Strategic processes or ‘selection for action’, which reflects “processes which reduce competition between potential responses to a stimulus” Carter et al. (1999, p. 1944; cf. Posner et al., 1988), were reduced by presenting a block of congruent items that should have resulted in the increase allocation of resources to word reading (see left side of figure 4). This manipulation is similar to that made by Carter et al., (2000) who found a particularly large Stroop interference effect in blocks consisting of a majority of congruent items. Immediately following this congruent block, which reduced strategic process and biased processing pathways to word reading, a block of incongruent items was presented. Since strategic processes were reduced and processing pathways biased to word reading then the first incongruent item immediately following the last congruent item should have required a reallocation of resources to colour naming thereby generate large response conflict and a particularly large Stroop interference effect (see centre of figure 5).

![Figure 5. Changes in the contribution of strategic processes to colour naming over a block of congruent and incongruent trials. Strategic processes to colour naming are reduced as responses are biased to word reading over a block of congruent trials. However, after conflict detection strategic processes to colour naming are increased thereby reducing the degree of conflict over a block of incongruent trials.](image-url)
The size of the Stroop interference effect generated from the first incongruent high conflict trials should reflect the relative efficiency of conflict detection, inhibition of dominant word reading processes and within trial adjustments in resource allocation to colour naming. A smaller Stroop interference effect would indicate more efficient detection of incongruence, or conflict, more efficient inhibition of word reading that enables recourse to be reallocated within trial to colour naming. This would provide a measure of cognitive inhibition.

Responses to subsequent incongruent items (i.e. incongruent items that followed the first incongruent item) would provide a measure of the adaptation to conflict that enhances context processing representations (i.e. respond to colour not word). This trial-by-trial adjustment in the allocation of resources from word reading to colour naming appears to be related to the degree of conflict generated on the previous trial (e.g. Gratton et al., 1992). Typically, the occurrence of an incongruent trial leads to an increased control over the response conflict on the subsequent incongruent trial. However, as strategic processes become more engaged over a number of incongruent trials, presumably reflecting an increased allocation of resources to colour naming, then the degree of conflict is reduced (see right side of figure 4) and so also is the amount trial-by-trial adjustment to conflict.

The amount of adjustment to conflict in the current experiment should therefore be greatest on the second incongruent trial. Strategic processes will increasingly become engaged and reduce the degree of conflict on subsequent incongruent trials thereby enhancing colour naming responses to them. This would provide the measure of context processing. Conflict detection during processing of the first incongruent trial should signal the need to enhance context representations (i.e. respond to colour not word). This trial-by-trial adjustment in the allocation of processing resources will increase colour naming processes and decrease word reading processes resulting in a reduction in conflict and an enhancement in behavioural performance on the 2nd incongruent trial. This ‘adaptation to conflict’ effect should therefore result in significantly faster reaction time responses to the 2nd incongruent trial than the 1st incongruent trial. A similar effect might also be observed with errors. The 2nd incongruent trial might generate a significantly smaller percentage of errors than the 1st incongruent trial.
Predictions and Hypotheses

Experiment 1 found no evidence for an inhibitory processing deficit in introvertive anhedonia. Introvertive anhedonia in the current study should therefore be unrelated to measures of Stroop interference (Hypotheses 1). Experiment 1 did, however, find some evidence for a context processing deficit in introvertive anhedonia. Introvertive anhedonia in the current experiment should therefore be negatively related to the degree of ‘adaptation to conflict’ (Hypothesis 2). The high introvertive anhedonic group should be unable to enhance context representations (i.e. respond to colour not word) when conflict on the 1st incongruent trial is detected resulting in decreased, or disabled, reallocation of processing resources from word reading to colour naming on the 2nd incongruent trial.

2.3.1: Experiment 2. Method

Introduction

Stroop experiment 2 explored differences in levels of introvertive anhedonia in detecting and adjusting behaviour to conflict. It addressed two experimental hypotheses by examining micro level, or trial-by-trial, adjustments in colour naming and word reading resources to the detection of conflict. It generated a high-conflict incongruent trial by biasing processing resources to word reading through the prior presentation of a block of congruent Stroop trials. Responses to this high conflict incongruent trial would provide a measure of Stroop interference and address hypothesis 1. Responses to incongruent items presented immediately after the high-conflict incongruent trial would provide a measure of ‘adjustment to conflict’ and the enhancement of context processing representations and address hypothesis 2.

The experiment emphasised response speed over accuracy for a number of reasons. Firstly, the conflict adaptation effects are greater under speed than accuracy emphasis (Carter & van Veen, 2007). Secondly, emphasising speed over accuracy should increase the proportion of errors, possibly making their analyses more robust. Thirdly, an emphasis on speed over accuracy, rather than emphasising speed and accuracy, might increase the likelihood that all participants use the same strategies while responding.
Participants

Fifty four participants were recruited into the study 77.8% of who were female. The sample had a mean age of 22.31 years with a standard deviation of 6.57. Recruitment procedures were identical to that of experiment 1. Participants were again invited to participate based on their O-LIFE introvertive anhedonia subscale scores and the allocation to low and high introvertive anhedonia groups was again based on normed age and gender introvertive anhedonia scores equal to or less than the 25th percentile and scores equal to or greater than the 75th percentile of a normed introvertive anhedonia distribution (Mason & Claridge, 2006; see Table 5). Efforts were made to recruit an equal number of participants to each group. Exclusion criteria were also identical to those in experiment 1 and participants were excluded from the study if known to have colour blindness, non-corrected vision less than 20/20 or being under the influence of substances known to distort mood, perception and or attention. The demographics of the high and low introvertive anhedonia groups was again not known until the end of data collection and are therefore reported in the results section.

Materials

The Stroop task was identical to that in experiment 1 but with a few notable exceptions. Four main stimulus blocks of 40 Stroop trials were created for the current experiment; each main block containing an equal occurrence of colour and word (e.g. the colour green occurred ten times and the word ‘Green’ occurred ten times. Each main stimulus block consisted of five unique sub-blocks of eight consecutively presented incongruent or congruent trials. Each congruent sub-block presented each colour word in its own ink colour twice while each incongruent sub-block presented each colour twice and each colour word twice. Two of the main stimulus blocks contained three unique sub-blocks of congruent trials and two unique sub-blocks of incongruent trials (i.e. block 2 and 4) while the other two main stimulus blocks (i.e. block 1 and 3) contained three unique sub-blocks of incongruent trials and 2 unique blocks of congruent trials (see appendix 2).
Procedure

Participant and experimental procedures were identical of those in experiment 1. However, in the current experiment, stimuli were presented in 3 presentation blocks; each were followed by a short break which participants ended and continued with the task by pushing the response box centre button. The first presentation block contained practice items to which participants had to achieve 80% response accuracy. The practice block was repeated until this criterion was met. The remaining 2 presentation blocks contained one of the 4 main stimulus blocks of 40 Stroop trials detailed in the materials section. For each participant, one of these stimulus blocks always contained a majority of congruent sub-blocks (i.e. stimulus block 2 or 4) while the other always contained a majority of incongruent sub-blocks (i.e. stimulus block 1 or 3). This resulted in eight possible combinations of stimulus blocks. Presentation of these incongruent and congruent sub-blocks were randomly counterbalanced so that a congruent sub-block always preceded an incongruent sub-block and an incongruent sub-block always preceded a congruent sub-block (see figure 5 below). The presentation of the eight trials within each congruent and incongruent sub-block, were fixed in a pseudorandom order ensuring that the print colour and colour word on any current trial was different to the word and/or print colour on the previous trial. This rule was also applied to the item at the beginning and end of each sub-block to ensure no priming effects between sub-blocks regardless of block presentation order.

Method of Analyses

The analyses were designed to explore the effects on reaction times and error proportion when trials switched from congruent colour word (e.g. word ‘Blue’ presented in blue ink) to incongruent colour word (e.g. word ‘Green’ presented in red ink). The first congruent or incongruent sub-blocks presented at each presentation block would have followed a testing break rather than another congruent or incongruent sub-block. These first congruent or incongruent sub-blocks were therefore excluded from the analyses (see figure 6). For each participant, eight mean congruent and eight mean incongruent reaction times were calculated from the remaining four congruent and incongruent sub-blocks (see figure 6). This provided a mean reaction time for eight consecutively presented congruent items (c1 to c8) followed by eight consecutively presented incongruent items (i1 to i8).
Experimental procedures placed an emphasis on response speed over accuracy in order to generate a greater proportion of errors for analyses and to ensure that all participants responded with the same response strategies. Global speed accuracy tradeoffs were therefore examined by comparing a speed-accuracy ratio, calculated by dividing the mean reaction time per trial by the mean accuracy percentage per trial (mean RT per trial / mean accuracy per trial). Response speed and accuracy can be considered to be inversely proportional; typically as reaction times slow then response accuracy increases. A larger speed-accuracy ratio would therefore indicate a reduction in accuracy at the cost of RT speed. Between groups analyses of the speed accuracy tradeoff ratio was conducted with an independent sample t-test. The remaining analyses were each presented in two parts to reflect the distinct processes under consideration: 1) analysis of Stroop interference and 2) analyses of conflict adjustment.

The first set of these analyses used multiple regression and logistic regression to account for the possible confounding influence of other schizotypal trait dimensions on the dependant measures of interest. Reaction times and errors were analysed, as both are equally valid dependent measures of the effects of interest.

The first multiple regression analyses examined reaction time Stroop interference (mean RT i1 minus mean RT c8) as the dependant variable and unusual experiences, impulsive non-conformity and cognitive disorganisation schizotypy dimensions as predictors. Data were screened for outliers, which if present were removed from the analyses. Furthermore, normality of the data was assessed and if significant skew were present then the particular variable was transformed until normality was achieved.

The measure of error Stroop interference (proportion of error to i1 minus proportion of error to c8) did not meet the testing assumptions for regression analyses. Its distribution...
was skewed and could not be normalised by transformations. The distributions were also leptokurtic as most observations were around zero. The measure of error Stroop interference was therefore recoded into a nominal variable consisting of an error Stroop interference effect category and a no error Stroop interference effect category and analysed in a logistic regression. The error Stroop interference effect category was defined by participants who had a greater proportion of errors to i1 than c8. The no error Stroop interference effect category was defined by participants who had either the same proportion of errors to c8 and i1 or a greater proportion of errors to c8 than i1. This nominal measure of error Stroop interference was included as the dependent variable in a binary logistic regression with the unusual experiences, impulsive non-conformity and cognitive disorganisation schizotypy dimensions as predictors.

A further multiple regression analyses examined reaction time adjustment to conflict (RTi1 minus RTi2) as the dependant variable and unusual experiences, impulsive non-conformity and cognitive disorganisation schizotypy dimensions as predictors. Data were screened for outliers, which if present were removed from the analyses. Furthermore, normality of the data was assessed and if significant skew were present then the variable was transformed until normality was achieved.

The measure of error adjustment to conflict (proportion of errors to i1 minus proportion of errors to i2) also did not meet the testing assumptions for regression analyses. It distribution was again skewed and could not be normalised by transformations. The distribution was also leptokurtic as most observations were around zero. The variable was therefore recoded into a nominal variable consisting of an error adjustment to conflict effect category and no error adjustment to conflict effect category and analysed in a logistic regression. The error adjustment to conflict effect category was defined by participants who had a smaller proportion of errors to i2 than i1. The no error adjustment to conflict effect category was defined by participants who had either the same proportion of errors to i1 and i2 or a greater proportion of errors to i2 than i1. This nominal measure of error adjustment to conflict was included as the dependent variable in a binary logistic regression with the unusual experiences, impulsive non-conformity and cognitive disorganisation schizotypy dimensions as predictors.

The final set of analyses examined Stroop interference effects and adjustment to conflict effects between the high and low extreme scoring introvertive anhedonia groups. Reaction times and error proportions were analysed separately for interference and adjustment to
conflict effects using 2-way mixed ANOVA’s with the high and low introvertive anhedonia groups as the between groups factor. Simple effects were analysed with repeated measures and independent samples t-tests and the Bonferroni method were used in instances where alpha required adjustment for multiple comparisons. When the data did not meet the homogeneity of variance assumption for an ANOVA, non-parametric tests were conducted and the error probability adjusted for multiple comparisons with the Bonferroni method.

2.3.2: Experiment 2. Results

Demographics

Mean ages and gender composition of the high and low introvertive anhedonia groups are presented in table 12. According to the criteria outlined in the method section, 27 participants were defined as low introvertive anhedonia and 27 as high introvertive anhedonia. The high and low introvertive anhedonia groups did not differ in age (t=0.514, df = 52, p>.05) and the groups were not associated with gender (p>.05 Yates correction) (see table 12).

<table>
<thead>
<tr>
<th>Gender</th>
<th>Low (n=27)</th>
<th>High (n=27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Age (mean/SD)</td>
<td>21.9 (6.3)</td>
<td>22.8 (7.0)</td>
</tr>
</tbody>
</table>

The high introvertive anhedonia group had higher mean unusual experiences, cognitive disorganisation, impulsive non-conformity and O-LIFE total score than the low group (see table 13). These group differences were not statistically significant for the impulsive non-conformity (t=0.107, df=52, p>.05) subscale scores. However, the high introvertive anhedonia group did have significantly higher unusual experiences (t=2.302, df=52, p<.05) and cognitive disorganisation (t=2.670, df=52, p<.01) subscale scores.
Table 13
O-LIFE total scores and subscale scores for the high and low introvertive anhedonia groups

<table>
<thead>
<tr>
<th></th>
<th>Low (n=27)</th>
<th>High (n=27)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean   (SD)</td>
<td>Mean      (SD)</td>
</tr>
<tr>
<td>Unusual Experiences</td>
<td>7.96   (5.65)</td>
<td>12.07   (7.36)</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>11.56  (4.70)</td>
<td>15.41  (5.84)</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>8.37   (3.22)</td>
<td>8.26    (4.33)</td>
</tr>
<tr>
<td>Introvertive anhedonia</td>
<td>1.22   (0.80)</td>
<td>11.19  (2.87)</td>
</tr>
<tr>
<td>O-LIFE Total</td>
<td>29.11  (9.67)</td>
<td>46.93  (13.54)</td>
</tr>
</tbody>
</table>

Experimental Analyses

Erroneous responses, consisting of 10.03% of the analysed data set, were removed from the analyses. Short and long extreme reaction times constituted a further 1.85% of the current data set were also removed. These extreme reaction times were defined by the same criteria for those outlined in experiment 1.

Speed Accuracy Tradeoff

In order to generate a greater proportion of errors for analyses and in attempting to ensure that all participants responded with the same response strategies the experimental procedures placed an emphasis on response speed over accuracy.

The possibility of different speed accuracy tradeoffs between the high and low introvertive anhedonia groups were therefore investigated by examining a speed-accuracy ratio, calculated by dividing the mean reaction time per trial by the mean accuracy proportion per trial (mean RT per trial / mean accuracy percentage per trial) for the high and low each introvertive anhedonia groups (table 14).
Table 14
Mean speed-accuracy ratio for the low and high introvertive anhedonia groups (SE)

<table>
<thead>
<tr>
<th></th>
<th>Speed Accuracy ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SE)</td>
</tr>
<tr>
<td>Low</td>
<td>2.30 (0.09)</td>
</tr>
<tr>
<td>High</td>
<td>2.40 (0.09)</td>
</tr>
</tbody>
</table>

An independent t-test found that the high and low introvertive anhedonia groups did not have significantly different speed-accuracy ratios ($t=0.792$, $df=52$, $p>.05$) indicating that the high and low introvertive anhedonia groups responded to the speed over accuracy instruction of the task to the same degree. This discounts a between groups difference in response strategy thus allowing more accurate interpretations of between groups effects in the reaction time and error data.

**Multiple Regression Analyses: Reaction Time Stroop Interference**

This regression analyses examined Stroop reaction time interference ($i1 - c8$) as the dependant variable with the schizotypy trait dimensions that were not of direct relevance to the current investigation as predictor variables. The dependant variable (Stroop interference) had one outlying case, which was removed form the analyses. Furthermore, the unusual experiences variable had significant skew and was subjected to square root transformation. All other variables were normally distributed.

The unusual experiences, impulsive non-conformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method but a significant model did not emerge ($F(3,49)=1.341$, $p>.05$) indicating that none of the included schizotypal dimensions were significant predictors of Stroop interference (see appendix 1. table A1.2 for coefficients of predictors).
**Logistic Regression Analyses: Error Stroop Interference**

A binary logistic regression analyses was conducted with a dichotomised measure of error Stroop interference effect as the dependent variable (no Stroop interference category: no difference in error between c8 and i1 or greater proportion of errors to c8 than i1 vs. Stroop interference category: greater proportion of errors to i1 than c8) and unusual experiences, impulsive nonconformity and cognitive disorganisation as predictor variables. A total of 54 cases were analysed but a significant model did not emerge (omnibus chi-square = 4.213, df = 3, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of error Stroop interference (see appendix 1. table A1.3 for coefficients of predictors).

**Multiple Regression Analyses: Reaction Time Adjustment to Conflict**

The second regression analyses examined the reaction time adjustment to conflict effect (i1 minus i2) as the dependant variable with the schizotypy trait dimensions that were not of direct relevance to the current investigation as predictor variables. The dependant variable (adjustment to conflict) had one outlying case, which was removed from the analyses. Furthermore, as in the previous regression the unusual experiences variable had significant skew and was subjected to square root transformation. All other variables were normally distributed.

The unusual experiences, impulsive non-conformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method. A significant model did not emerge (F(3,49)=1.234, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of adjustment to conflict (see appendix 1. table A1.4 for coefficients of predictors).
Logistic regression analyses: Error Adjustment to Conflict

A binary logistic regression analyses was conducted with a dichotomised measure of error adjustment to conflict effect as the dependent variable (no adjustment to conflict effect category: no difference in error between i1 and i2 or greater proportion of errors to i2 than i1 vs. adjustment to conflict effect category: greater proportion of errors to i1 than i2) and unusual experiences, impulsive nonconformity and cognitive disorganisation as predictor variables. A total of 54 cases were analysed but a significant model did not emerge (omnibus chi-square = 1.795, df = 3, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of error adjustment to conflict (see appendix 1. table A1.5 for coefficients of predictors).

Introvertive Anhedonia Between Groups Analyses of Effects

The mean reaction times of (a) Stroop interference and (b) adjustment to conflict for the high and low introvertive anhedonia groups are presented in figure 7. The mean percentage of errors for the same effects for the high and low introvertive anhedonia groups are presented in figure 8. Both the high and low introvertive anhedonia groups have longer reaction times and greater proportion of errors to i1 than c8 trial, which indicates the presence of a Stroop interference effect. The magnitude of this difference appears to be larger for the low than the high introvertive anhedonia group in the reaction time data but comparable in the error data. Furthermore, both the high and low introvertive anhedonia groups have faster reaction times and a smaller proportion of errors to i2 than i1, which indicates the presence of a conflict adjustment effect. These effects appear to be larger for the low than the high introvertive anhedonia group, which will be analysed in detail below.
Figure 7. Mean reaction times in milliseconds of the high and low introvertive anhedonia group displaying (a) Stroop interference: the 8\textsuperscript{th} congruent [c8] and the 1\textsuperscript{st} incongruent [i1] item and (b) adjustment to conflict: the 1\textsuperscript{st} incongruent [i1] item followed by the 2\textsuperscript{nd} incongruent [i2] item. (error bars represent SE of the mean).

Figure 8. Mean percentage of errors of the high and low introvertive anhedonia group displaying (a) Stroop interference: the 8\textsuperscript{th} congruent [c8] and the 1\textsuperscript{st} incongruent [i1] item and (b) adjustment to conflict: the 1\textsuperscript{st} incongruent [i1] item followed by the 2\textsuperscript{nd} incongruent [i2] item (error bars represent SE of the mean).
ANOVA of Reaction Time Stroop Interference

The analyses first examined Stroop interference. The parameters of the current Stoop colour word task reduced macro level strategic cognitive processes by biasing processing pathways to word reading through the consecutive presentation of eight congruent Stoop items. The presentation of an unexpected incongruent item would require mismatch or conflict detection and a micro level reallocation of resources to colour naming.

Theoretically, Stroop interference should be at its greatest for the first incongruent item presented immediately following the presentation of a block of congruent items. For the purpose of the current analyses the largest degree of Stroop interference generated by the paradigm was therefore measured as the reaction time difference between the 1st incongruent item (i1) and the 8th congruent item (c8) (see figure 7 section a) with longer mean reaction times for i1 than c8 indicating the presence of Stroop interference. Both the high and low introvertive anhedonia groups produced longer reaction times to i1 than c8 trial, which indicates the presence of a Stroop interference effect. The magnitude of this difference also appears larger for the low than the high introvertive anhedonia group.

Mean reaction times for c8 and i1 were subsequently analysed in a two-way congruence (c8 vs. i1) by introvertive anhedonia group (high vs. low) mixed ANOVA. It revealed a main effect of congruence (F(1,52)=93.716, p<.001, \( \eta^2 = .643 \)) indicating the presence of a global Stroop interference effect as reaction times were on average significantly slower to i1 trials (M=771, SE=23, CI_{95} = 573, 649) than c8 trials (M=611, SE=19, CI_{95} = 724, 818). There was no main effect of group (F(1,52)=0.473, p>.05), indicating that the high (M=705, SE=28) and low (M=678, SE=28) introvertive anhedonia groups did have significantly different global reaction times. The analyses also found no congruence by introvertive anhedonia group interaction (F(1,52)=0.688, p>.05) indicating that the size of the Stroop interference effect did not differ between the high (M=146, SE=23, CI_{95} = 99, 193) and low (M=173, SE=23, CI_{95} = 126, 220) introvertive anhedonia groups.

Planned comparisons conducted with 2 paired samples t-tests confirmed that reaction time responses were significantly slower for i1 than c8 for both the low (t=7.068, df=26, p<.001, Cohen’s d=1.36) and high (t=6.618, df=26, p<.001, Cohen’s d=1.27) introvertive anhedonia groups. Furthermore, a between groups t-test showed that the high and low introvertive anhedonia group did not differ in their responses to the 8th congruent item (c8) (t=1.071, df=52, p>.05) or the 1st incongruent item (i1) (t=0.285, df=52, p>.05).
The analyses of c8 and i1 reaction times revealed a large statistically significant global Stroop interference effect. However, the low and high introvertive anhedonia groups did not generate different amounts of Stroop interference. Furthermore, the low and high introvertive anhedonia group did not generate significantly different reaction times to the last congruent item (c8) or the first incongruent item (i1).

ANOVA of Error Stroop Interference

The amount of Stroop error interference was measured as the difference between the percentages of errors generated from responses to the 1st incongruent item (i1) and the 8th congruent item (c8). The high and low introvertive anhedonia groups generated an identical percentage of errors for the 1st incongruent item (i1) and the 8th congruent item (c8) and therefore did not differ in the amount of Stroop error interference (Figure 7 section a). ANOVA was therefore not conducted. However, a paired samples t-test examining global effects found that the percentage of errors for i1 (M=13.9, SE=17.3) was significantly higher than the percentage of errors for c8 (M=6.5, SE=11.1) (t=2.356, df=53, p<.01, Cohen’s d=0.42) indicating the presence of a global Stroop error interference effect.

The analyses of c8 and i1 error proportions revealed a statistically significant global Stroop interference error effect. According to Cohen’s effect size indices, the interference error effect size was medium. However, the size of the interference error effect did not differ between the low and high introvertive anhedonia groups.

ANOVA of Reaction Time Adjustment to Conflict

The analyses subsequently examined the behavioural adjustment to processing the conflict generated by the first incongruent item (i1). The consecutive presentation of eight congruent items biased response pathways to word reading and reduced strategic processes thereby generating particularly large Stroop interference when an unexpected incongruent item was presented. The subsequent reallocation of cognitive resources to colour naming pathways should therefore lead to behavioural adjustment on subsequent incongruent trials. For the purpose of the current analyses adjustment to conflict was measured as lower mean reaction times to the 2nd incongruent item (i2) that immediately followed the 1st incongruent item (i1). Both the high and low introvertive anhedonia groups produced
faster reaction times to i2 than i1, which indicates the presence of a conflict adjustment effect. These effects appear to be larger for the low than the high introvertive anhedonia group.

Means for i1 and i2 were analysed in a two-way conflict adjustment (i1 vs. i2) by introvertive anhedonia group (high vs. low) mixed ANOVA. It revealed a main effect of conflict adjustment (F(1,52)=6.507, p<.05, $\eta^2 = .111$), which indicated the presence of a global adjustment to conflict effect as reaction times were on average significantly slower to i1 trials (M=771, SE=23, CI$_{95} = 724, 818$) than i2 trials (M=731, SE=21, CI$_{95} = 688, 773$). The analysis further revealed no main effect of group (F(1,52)=.377, p>.05), indicating that the high (M=764, SE=30) and low (M=738, SE=30) introvertive anhedonia group did not differ in their global reaction times. Furthermore, no conflict adjustment by introvertive anhedonia group interaction (F(1,52)=0.622, p>.05) was found, indicating that the high (M=28, SE=22, CI$_{95} = 17, 72$) and low (M=52, SE=22, CI$_{95} = 8, 97$) introvertive anhedonia group did not differ on the size of conflict adjustment.

Due to the absence of a predicted conflict adjustment by introvertive anhedonia group interaction, the critical alpha value for the significance of planned contrasts was adjusted for 2 comparisons and set at .025. Repeated measures t-tests subsequently found that the low introvertive anhedonia group produced a significant conflict adjustment effect, that is, significantly faster reaction time responses to i2 than i1 (t=2.329, df=26, p<.025, one tailed, Cohen’s d=0.44). However, no such effect was present for the high introvertive anhedonia group (t=1.264, df=26, p>.025, one tailed).

The analyses of i1 and i2 reaction time data revealed a statistically significant global adjustment to conflict effect. According to Cohen’s effect size indices, the conflict adjustment effect size was small. However, while the low introvertive anhedonia group generated a significant adjustment to conflict effect the high introvertive anhedonia group did not.

**ANOVA of Error Adjustment to Conflict**

Adjustment to conflict error effect was measured as a lower mean percentage of errors from responses to the 2nd than the 1st incongruent item. Both the high and low introvertive anhedonia group displayed an adjustment to conflict error effect (see Figure 7 section b).
However, the low introvertive anhedonia group produced a larger amount error adjustment to conflict (7.5% change) than the high introvertive anhedonia group (1.8% change).

The homogeneity of variance assumption was violated for the data from the 2nd incongruent item (i2), which prevented the use of ANOVA. The variance of the i2 data significantly differed between the high and low introvertive anhedonia groups (F(1,52)=4.146, p<.05). Examination of the distribution of i2 errors for the high and low introvertive anhedonia groups indicated that skew was comparable in direction and extent but that kurtosis was smaller for the high introvertive anhedonia group (see figure 9).

![Figure 9. Distribution of error percentage of the 2nd incongruent item for the high and low introvertive anhedonia groups.](image)

The analyses therefore used non-parametric tests, as they are insensitive to the distribution of the data. A Wilcoxon signed ranks tests found a global conflict adjustment error effect (z=1.672, p<.05, one tailed). The subsequent analyses of the conflict adjustment error effect in the high and low introvertive anhedonia group adjusted the alpha value for significance for two comparisons and set at .025. The analyses found that while the low introvertive anhedonia group produced a significant adjustment to conflict error effect, that is, a significantly lower percentage of errors for i2 than i1 (z=1.999, p<.025, one tailed, Cliff’s d= 0.21), the high introvertive anhedonia group did not (z=0.465, p>.025, one tailed).
The analyses of i1 an i2 error percentage revealed a statistically significant adjustment to conflict error effect in the low introvertive anhedonia group but not in the high introvertive anhedonia group. According to Cliff’s nonparametric effect size indices (Cliff, 1993), size of the low introvertive anhedonia groups’ adjustment to conflict error effect was small.

### 2.3.3: Experiment 2. Discussion

#### Summary of Findings

The analyses of c8 and i1 reaction times and percentage of errors indicated that both the high and low introvertive anhedonia groups generated a classic Stroop interference effect. Both groups generated significantly faster reaction times and significantly fewer errors whilst responding to the 1st incongruent item (i1) than the 8th congruent item (c8). The high and low introvertive anhedonia groups did not, however, differ in the magnitude of Stroop reaction time or error interference.

The analyses of i1 and i2 reaction time and error data found that while the low introvertive anhedonia group generated a significant adjustment to conflict effect the high introvertive anhedonia group did not. The low introvertive anhedonia generated significantly faster reaction times and significantly fewer errors whilst responding to the 2nd incongruent item (i2) then the 1st incongruent item (i1). These results and their implication will be considered further below.

#### Stroop Interference Effects

Both the high and low introvertive anhedonia group generated faster mean reaction times to congruent than incongruent stimuli, which is indicative of a classic Stroop interference effect. However, despite the low introvertive anhedonia group generating a larger (173ms) interference effect than the high group (146ms), this difference was not significant. These results are consistent with hypotheses 1 which predicted that levels of introvertive anhedonia would be unrelated to Stroop interference.
The pattern of data was similar to that of experiment 1 in that the reaction time differences between the high and low introvertive anhedonia groups were disproportional at the 8th congruent item and at the 1st incongruent item. Despite these similarities, the difference in size of the Stroop interference effect between the high and low introvertive anhedonia groups in the current experiment was not significant.

A significantly greater proportion of errors were also made whilst responding to the 1st incongruent item than the 8th congruent item, which indicates the presence of a significant global Stroop interference error effect. Furthermore, the high and low introvertive anhedonia groups generated an identical proportion of errors for both the 8th congruent and 1st incongruent items. Levels of introvertive anhedonia were therefore unrelated to Stroop error interference, which is again consistent with hypotheses 1.

In sum, there was no evidence that the high and low introvertive anhedonia groups differed on the size of Stroop interference, which is consistent with experimental hypothesis 1. This suggests comparable efficiency, in the high and low introvertive anhedonia groups, of conflict or mismatch detection mechanisms, the inhibition of prepotent word reading responses and within trials adjustment in resource allocation to colour naming.

**Conflict adjustment Effects**

Significantly faster reaction time responses to the 2nd incongruent item (i2) than the 1st incongruent items (i1) indicated the presence of a global adjustment to conflict effect. This suggests that participants behaviourally adjusted to the processing of high conflict generated by the first incongruent item. However, while the low introvertive anhedonia group produced a significant adjustment to conflict reaction time effect the high introvertive anhedonia group did not. Hypothesis 2 was therefore supported.

A global adjustment to conflict error effect, characterised by a smaller percentage of errors to the 2nd incongruent item (i2) than the 1st incongruent items (i1), was also observed in the error data. Furthermore, while the low introvertive anhedonia group generated a significant adjustment to conflict error effect, the high introvertive anhedonia group did not. These results again supported hypothesis 2.
Synthesis

Reaction time and error data indicate that high and low introvertive anhedonia group produced Stroop interference effects of comparable magnitude suggesting that inhibitory control is functioning to the same degree in both groups. However, the reaction time and error data suggest that only the low introvertive anhedonia group behaviourally adjusted to the high degree of conflict generated by the first incongruent items by responding with greater speed and accuracy to the subsequent incongruent items. This is consistent with conflict adaptation effects (e.g. Gratton et al. (1992) reviewed in the introduction where the occurrence of incongruence is thought to signal the requirement for control (Botvinick et al., 2001; Carter et al., 2000; Kerns et al., 2004), which subsequently leads to the enhancement of context processing representations (Botvinick et al., 2001; Miller and Cohen, 2001) and greater cognitive control over the response conflict of subsequently presented incongruent trials.

These results suggest that the high introvertive anhedonia group have a context processing dysfunction specifically characterises by a deficit in strengthening representations of context. The implementation of cognitive control on post conflict trials would require the enhancement of context representations (i.e. respond to colour not word) (e.g. Cohen & Servan-Schreiber, 1992) that results in the reallocation of cognitive resources to colour naming. A deficit in context processing would therefore result in problems in reallocating resources to colour naming.

Alternatively, the high introvertive anhedonia group have a deficit in signalling the requirement for control. Comparable Stroop interference effect in the high and low introvertive anhedonia group preclude the possibility that group differences in the functioning of mismatch or error detection mechanisms contribute to the absence of behavioural adaptation to conflict in the high introvertive anhedonia group. Error or mismatch detection mechanisms in high introvertive anhedonia therefore appear to be intact. However, the signal that indicates the requirement for increase control might be diminished.
Methodological Problems

Experiment 1 could not attribute effects of interest solely introvertive anhedonia and the results suggested that context processing deficits might be related to global schizotypy scores. The current experiment had a similar methodological confound as the high introvertive anhedonia group were not only significantly higher than the low group on levels of introvertive anhedonia but also on levels of unusual experiences and cognitive disorganisation, the O-LIFE’s measure of positive schizotypy and disorganisation. However, unlike experiment 1, multiple regression and logistic regression analyses indicate that reaction time and error measures of Stroop interference and adaptation to conflict were unrelated to unusual experiences, cognitive disorganisation and impulsive non-conformity schizotypy dimensions and global schizotypy scores.

Conclusions

Analyses of Stroop interference effect in the current experiment suggests that the high and low introvertive anhedonia groups have comparably efficient conflict or mismatch detection mechanisms, similar abilities to inhibit proponent word reading responses and adjust resources allocated to colour naming within a trial. The analyses of adjustment to conflict effects indicate that while the low introvertive anhedonia were able to behaviourally adjust their responses to conflict the high introvertive anhedonia were not. Two possibilities might account for reduced conflict adjustment in the high introvertive anhedonia group. Firstly, the high introvertive anhedonia group have reduced ability to enhance context processing representations. Secondly, the high introvertive anhedonia group have a deficit in generating signals for the requirement of enhanced control. Both accounts would implicate a cognitive deficit that prevents the flexible adaptation of behaviour to new and complex situations.

2.4: Interim Discussion 1

Experiment 1 and 2 address objective 1 of the thesis and sought to determine whether negative schizotypy, as measured by the O-LIFE’s introvertive anhedonia subscale, was associated with a generalised executive functioning abnormality. The Stoop colour word task was used to address this aim as performance on the task it is thought to require frontal
lobe executive functioning in inhibiting irrelevant stimuli and focusing attention (Lezack, 1995). A further conceptualisation of the task suggests that it requires reliable internal representation of context (Cohen & Servan-Schreiber, 1992). These representations are thought to be the task instruction to ‘respond to colour and ignore the word’. During conflict Stroop trials, when a colour word is presented incongruously with its ink colour, a stable and reliable internal representation of context is required to strengthen colour naming processing in order to correctly respond to the ink colour and ignore the colour word’s semantic meaning.

A review of schizophrenia and schizotypy Stroop colour word studies revealed two major inconsistencies that prevented sound conclusions and predictions to be made regarding which schizophrenia/schizotypy symptom/trait dimension might be associated with deficits on the Stroop task. Firstly, there were variations in the methodology used between schizophrenia studies, which generated different patterns of data and therefore affected interpretations. The most notably difference was the use of a single trial computerised version of the task versus a traditional list-based paper version. This confounded the second problem that the Stroop task methodology reported in many schizotypy studies were vague or absent making comparisons between studies impossible.

Experiment 1 intended to provide a methodological baseline from which to examine executive functioning deficits in the negative trait dimensions. It also aimed to examine whether an inhibitory deficit or a context processing deficit best accounts for the executive functioning deficits in negative schizotypy. The experiment examined performance of extreme scoring high and low introvertive anhedonia groups on a single trial version of the Stroop task that presented an equal proportion of congruent, incongruent and neutral trials. These trial propositions intended to increase resource allocation to colour naming thereby enhancing context representations (i.e. respond to colour not word) that would result in disproportionately enhanced reactions to neutral trials compared to incongruent trials leading to particularly large Stroop interference effects. A larger Stroop interference effect in negative schizotypy would therefore suggest an inhibitory processing deficit driven by slower reaction times to incongruent trials while a smaller interference effect would suggest a context processing deficit that was driven by slower reactions to neutral trials.

Manipulation of trial proportions were also expected to eliminate Stroop facilitation effects, and their absence in the experiment 1 suggests that the manipulation of trial
proportions had the intended effect. The remaining results indicated that the high introvertive anhedonia group generated a smaller Stroop interference effect than the low introvertive anhedonia group, which suggested a deficit in processing context. However, predictions were only partly supported, as the smaller Stroop interference effect in the high introvertive anhedonia group was not particularly driven by slower responses to neutral trials. This suggested that responses from both incongruent and neutral trials contributed to smaller Stroop interference effect in the high introvertive anhedonia group with non-significant speeding on incongruent trials and non-significant slowing on neutral trials. This might imply the enhanced operation of inhibition on incongruent trials and the operation of a deficit in context processing on neutral trials. However, the absence of significant difference between high and low introvertive anhedonic groups on incongruent and neutral trials prevented concrete conclusions.

The results of experiment 1 generally support a context processing deficit in high introvertive anhedonia but intact inhibitory processing. It was argued that the trial proportion effects of experiment 1 resulted in a macro level adjustment in the resources allocated to colour naming and word reading. However, the inability to adequately separate effects of inhibition and context processing prevented firm conclusions. Stroop experiment 2 therefore aimed to address the limitations of experiment 1 and also intended to find supporting evidence for a context processing deficit in high introvertive anhedonia by examining micro level, or trial-by-trial, adjustment in resources allocated to colour naming.

Responding to an incongruent trials on the Stroop colour word task requires a regulative cognitive control function, in order to increase colour naming processing, but also an evaluative component that detects conflict and signals the requirement for control. Experiment 2 aimed to measure both regulative cognitive control and evaluative conflict detection components of responding to incongruent Stroop stimuli. The experiment aimed to increase the size of Stroop interference by biasing processing to word reading through block presentation of congruent Stroop stimuli. Stroop interference and the detection of conflict were then assessed through performance to a subsequently presented and unexpected incongruent Stroop colour word stimulus. The high degree of conflict generated by this incongruent stimulus (i.e. conflict trial n) is thought to signal the requirement for control, which leads to the enhancement of context processing representations (Botvinick et al., 2001; Miller and Cohen, 2001) and greater cognitive control over the response conflict of subsequently presented incongruent trials. The
amount of cognitive control applied or adaptation to conflict was therefore assessed through performance to a second incongruent Stroop stimulus (i.e. conflict trial n+1).

Experiment 2 found a global Stroop interference effect, that is longer reaction times to the first incongruent conflict trial than the previous congruent no-conflict trial. Furthermore, there were no differences in the magnitude of the Stroop interference effect between the high and low introverted anhedonia groups, suggesting that they did not differ in their ability to reallocate processing resources to colour naming within a trial. However, significantly better performance was observed in the low introverted anhedonia group on the 2nd conflict incongruent trial than the 1st conflict incongruent trial. This suggested that while both the high and low introverted anhedonia groups detected the high-conflict generated by incongruent colour word conflict on trial n only the low introverted anhedonia group benefited from this conflict by producing an enhancement in performance on subsequently presented incongruent colour word conflict on trial n+1. The results suggest that while inhibitory mechanisms were operating comparably in the low and high introverted anhedonia groups, cognitive control functions of the high group are disrupted. That is, the high introverted anhedonia group were either unable to generate the conflict detection signal of the requirement for increased cognitive control or they were unable to use or implement such signal to enhance context representations (i.e. respond to colour not word).

In sum, the results of experiment 1 and 2 indicate that high introverted anhedonics have an executive control disability. Experiment 1 suggests that such a disability can be characterised as a deficit in context processing. The trial proportions of experiment 1 were argued to influence macro level resource allocation such that context representations (i.e. respond to colour and ignore the word) were enhanced. Manipulations of micro level, or trial-by-trial, adjustments in resources allocated to colour naming were conducted in Experiment 2. The experiment found supporting evidence for a context processing deficit in high introverted anhedonia. They may have been unable to use, or implement, signals of the requirement for increased control, normally triggered by high conflict on trial n, to enhance context representations (i.e. respond to colour not word) and increasing colour naming processing on trial n+1.

These results address objective 1 of the thesis and suggest that negative schizotypy is associated with cognitive deficit of the central executive that can be characterised as a specific problem in processing context. However, the precise nature of the processes
underpinning effects observed in experiment 2 require further study. High introvertive anhedonics might be unable to generate signals of the requirement to enhance cognitive control or might be unable to implement these signals to enhance representations of context representations (i.e. respond to colour not word) that would increase resources to colour naming.

These research questions will not be investigated further and the next section will address objective 2 of the thesis. The possibility of an emotion cue processing abnormality in introvertive anhedonia will be explored over the next three experiments. Experiment 1 and 2 used, with some success, the Stroop colour word task in exploring a generalised cognitive abnormality in introvertive anhedonia. It therefore seems logical to use the emotional Stroop task, which is a modified version of the Stroop colour word. Stroop task. Although the two tasks share a name there are a number of conceptual differences between them that will be addresses in detail in the following introduction to experiment 3. Essentially, while the Stroop colour word task assesses the ability to inhibit proponent word reading responses, the emotional Stroop task assesses how much an emotional word detracts cognitive resources from the task of colour naming. It can therefore be viewed as a measure of the depth at which an emotional cue is processed. The emotional Stroop task has also proved its usefulness by being extensively used in assessing emotion cue processing in anxiety. Furthermore, due to the scarcity of schizotypy emotional Stroop studies, the emotional Stroop review in the following section will make frequent reference to anxiety research to help describe the emotional Stroop task and characterise the cognitive processes that are associated with it.
Chapter 3:

Emotion Cue Processing in Introvertive Anhedonia
3.1: Experiment 3. Emotional Stroop

The preceding two experiments addresses objective 1 of the theses by exploring the possibly of a generalised executive deficit in negative schizotypy. These experiments suggested that high introvertive anhedonics have an executive processing deficit that is characterised by disruptions in context processing. The following section will now address objective 2 of the thesis by using the emotional Stroop task to explore the possibility of an emotion cue processing deficit in negative schizotypy. The emotional Stroop task is thought to assess how much an emotional word stimulus detracts cognitive resources from the primary task of colour naming. It has proved its usefulness in numerous studies that assess emotion cue processing in trait anxiety. These studies of anxiety will be used in the following review, due to the scarcity of studies using the emotional Stroop task with schizotypy samples, to help describe the task and characterise the cognitive processes that underpin its effects

The Emotional Stroop Task

The emotional Stroop Task is a variant of the classic Stroop Colour-Word task. Instead of colour words it uses neutral words, emotional words, threat words or words related to a specific pathology and is often used as a measure of attentional bias. Colour naming performance is particularly disturbed when the to-be-ignored word is related to a specific pathology (e.g. anxiety, depression, post traumatic stress disorder, obsessive compulsive disorder or specific phobias) (see Williams et al., 1996, for review) or even a particular concern. For example, Dalgleish (1995) obtained emotional Stroop effects using bird names with ornithologists. Such results suggest that the stimulus is harder to ignore/inhibit while trying to identify ink colour as the word stimuli is demanding of attention. The task seems to involve some kind of executive control such as cognitive inhibition or selective attention. It has traditionally been considered to involve similar attentional processes as the classic Stroop Colour-Word task (Pratto & John, 1991). Both tasks share a number of features; they both involve the presentation of words with different colour print and the naming of the print colour in which the words are presented. Furthermore, both tasks measure the influence of the task irrelevant semantic content of the word on colour naming. However, Chajut, Lev and Algom (2005) state that the classic Stroop and emotional Stroop tasks have fundamental differences in a number of dimensions including conceptual, construal, measurement model and sensitivity to manipulation.
Theoretical Differences: Emotional Stroop vs. Stroop Colour Word

Algom, Chajut and Lev (2004) note that emotional Stroop stimuli lack the defining features of classic Stroop colour word stimuli, namely the existence of a logical relationship between their components (i.e. the presence or absence of congruence). They argue that several qualifications apply when clarifying Stroop stimuli. The first is that the presence of congruence or incongruence depends on the demand of the task. Values from the two dimensions of congruent stimuli are associated with the same task-appropriate response. However, the value of one dimension of incongruent stimuli is associated with one task-appropriate response while value of the other dimension is associated with a different task-appropriate response. The example given by Algom et al. (2004) is that an upward pointing coloured arrow is a Stroop stimulus in a top-bottom spatial location task but not in a colour naming task. The second qualification is that at least one dimension of the stimuli be semantic in nature. The relationship linking the two dimensions cannot exist without semantic involvement. For original Stroop stimuli, colour word is semantic whereas ink colour is not. Further, both dimensions of Stroop stimuli consisting of pictures and words are semantic. In contrast, abstract form and colour are not semantic and therefore cannot be Stroop stimuli. The third qualification is that the semantic association between stimuli not only come from the ‘natural’ meaning that words acquire through the normal course of linguistic development, as in Stroop’s classic experiment, but they may also come from environmental correlations (e.g. grass and green or sky and blue) or may also have incidental associations (e.g. chocolate and brown). Algom et al. (2004) conclude that the various sources of semantic associations are likely to create Stroop conflict at different levels of intensity. However, the dimensions are Stroop dimensions because the stimuli divide into congruent and incongruent combinations.

Emotional Stroop stimuli, however, correspond only to the second qualification that at least one dimension be semantic in nature. Emotional Stroop stimuli lack the logical relationship of congruence or incongruence. For example, the word *cancer* presented in *green* ink is no more congruent than the word *Table* presented in *blue* ink. These stimuli cannot be divided into congruent and incongruent combinations. Furthermore, emotional Stroop stimuli lack unique semantic associations. For example the word *chair* is not associated with (or dissociated from) any one particular ink colour. As such, Algom et al. (2004) noted that the Stroop effect is an item based phenomenon. Stroop interference can be calculated with individual items. For example, item-specific Stroop interference can be calculated as the difference in colour naming the word *red* appearing in two different
colours, red (matching) and blue (mismatching). In contrast, the emotional stoop effect is a list based phenomena, as item specific effects do not present.

**Empirical Differences: Emotional Stroop vs. Stroop Colour Word**

In a number of experiments Algom et al. (2004) demonstrated the separability of the emotional Stroop from the classic Stroop colour word effect. They found the two tasks to be distinct in six ways: (a) The emotional Stroop effect was not found to be sensitive to task-irrelevant variation and was present when only one emotional word and one neutral word was used. In contrast, the classic Stroop effect is sensitive to task irrelevant variation and was absent when, for example, only one colour word is used (i.e. RED) that varies in its print colour over a number of trials. This reflects the classic Stroop task’s nature as a measure of selective attention. (b) A hallmark of the classic Stroop effect is asymmetry between reading colour and naming words. Good performance with word reading comes in tandem with poor performance with colour naming and vice versa, again reflecting the classic Stroop task as a measure of selective attention. In contrast, the emotional Stroop effect does not display colour-word complementarity in interference. (c) The emotional Stroop effect was not sensitive to changes in the relative salience of each dimension. When colours and words were made equally salient, emotional words still disrupted word reading and colour naming. In contrast, classic Stroop effect can be reversed and eliminated by changing the relative salience of words and colour, again reflecting the task as a measure if selective attention. (d) Implicating a generic emotional inhibitory mechanism, emotional words interfere with reading and colour naming, suggesting that threatening stimuli disrupts all ongoing activity. However, as mentioned above, the classic Stroop effect is characterised by asymmetry between word reading and colour naming, again separating it from an emotional Stroop effect and indicating it as a measure of selective attention. (e) The emotional Stroop effect is sensitive to the way that the emotional and neutral items are presented. It diminishes or vanishes when different items (emotional and neutral) appear in the same block reflecting its nature as a list based phenomena. In contrast, the classic Stroop effect is observable and robust with mixed presentation reflecting it as an item based phenomena. (f) The emotional Stroop effect was still present when reading words was replaced by lexical decision again suggesting the disruption of all ongoing processes by the emotional threat stimuli. In contrast, the classic Stroop effect is sensitive to alternative task demands (Smith & Magee, 1980).
Explanation of the Effect: Automatic vs. Controlled Processes

Algom et al. (2004) argued that the theoretical differences and the six empirical differences found between the emotional Stroop and classic Stroop tasks suggests that different mechanisms underpin each effect. They conjectured that the data implicated a generic cognitive slowdown in response to processing of negative threatening stimuli in the emotional Stroop task. They used the term automatic activation to describe this general-purpose defence mechanism. Various researchers have proposed that threat-driven mechanisms are automatic (e.g. Chen & Bargh, 1999; Pratto & John, 1991; Wentura, Rothermund & Bak, 2000) and occur early in a continuum model of consciousness (Ohman, 1988) where affective information is processed before more complex perceptual features of the stimulus. Ohman, Flykt & Esteves (2001) suggested a distinction between preattentive visual attention that is fast, automatic and parallel and postattentive visual attention that is slow, deliberate and serial. These interpretation are consistent with the dominant account of emotional Stroop (e.g. Williams et al., 1996) which proposes that anxiety is accompanied by an automatic attentional bias to potentially threatening stimuli, leading to interference in colour naming.

Phaf and Kan’s (2007) meta analyses of the automaticity of emotional Stroop included studies with both clinical and non-clinical trait anxious groups when threat words were presented either optimally (i.e. clearly visible) and sub optimally (i.e. very brief presentation) and when trials were either mixed (presenting both emotional and neutral stimuli) or blocked (presenting either emotional or neutral stimuli). The analyses however precluded studies using a suboptimal blocked design due to their low number. Phaf and Kan (2007) argued that the presence of an automatic process could show up with either optimal or suboptimal word presentation though an effect with suboptimal presentation would provide better evidence for automaticity. The analyses found that a combined effect size for a suboptimal emotional Stroop effect was virtually zero but a significant interference effects was found with mixed optimal presentation. Phaf and Kan (2007), however, discounted this as evidence for an automatic process in emotional Stroop due to the probable action of a slow emotional Stroop effect (Mckenna and Sharma, 2004) or carry over effect (Waters, Sayette and Wertz, 2003).

In a series of emotional Stroop experiments Mckenna and Sharma (2004) presented emotional word Stroop stimuli followed by six consecutively presented neutral word Stroop stimuli. They found no evidence for a fast mechanism disrupting processing on
current items but instead discovered a slow processing mechanism, which they called the slow emotional Stroop effect, operating between items and disrupting reaction times on subsequent items to the emotional stimuli. Consistent with Algom et al.’s (2004) findings that the emotional Stroop effect is a list based phenomena, Waters et al. (2003) suggested that the slow component, or carry over effect, may reduce the size of the emotional Stroop effect on the mixed Stroop task possibly due to the salience of the emotional stimuli affecting responses to neutral stimuli. A genuinely random presentation order involves some repetition of emotional and control trials (e.g. Mckenna & Sharma 2004) and Phaf and Kan (2007) argued that these ‘mini-blocks’ might have been responsible for the effect found with mixed random presentation. Supporting this conclusion, Phaf and Kan (2007) found that the effect sizes doubled in all groups when stimuli were presented in blocks. On the other hand, the presence of a slow emotional Stroop effect may also theoretically reduce or abolish an emotional Stroop effect with mixed suboptimal stimuli. The data do not, therefore, absolutely discount the presence of an automatic emotional Stroop effect since studies with blocked suboptimal presentation were excluded from Phaf and Kan’s (2007) analyses. However, the existence of a slow emotional Stroop effect suggests that processes other than an automatic bias may contribute to the effect. Several researchers have proposed the involvement of relatively late controlled attentional processes. De Ruiter and Biosschot (1994) suggested that the emotional Stroop effect reflects the effortful avoidance of processing threat cues rather than attentional capture. Similarly, Waters et al. (2003) propose that the emotional Stroop task may reflect a difficulty in disengaging attention from emotionally salient stimuli.

Bar-Haim, Larny, Pergamin, Bakermans-Kranenburg and van ljendoorn (2007) conducted meta analyses of threat related attentional bias and included studies employing the emotional Stroop task and those using a dot probe paradigm. It excluded studies that distinguish between an ‘engage’ and ‘disengage’ component of attention due to their low number and because these components were constantly examined in within-subjects design, thus precluding meta-analytic examination. The analyses found that subliminal and supraliminal threat stimulus presentation captured anxious individuals’ attention. However, the effect size was smaller with subliminal than with supraliminal presentation suggesting that a larger part of threat related biases results from processes that require attention. Furthermore, preconscious and conscious processes were found to be differentially tapped by the emotional Stroop and dot probe paradigms. Although combined effect sizes in anxious participants were significant with both subliminal and supraliminal presentation of threat stimuli in the emotional Stroop task, the latter was
significantly larger, suggesting that conscious post attentive processes play a prominent role in the paradigm. Supraliminal presentation of threat words in the emotional Stroop task might create greater conflict with the task demand thus requiring greater cognitive control. The reverse pattern was observed in dot probe studies. Subliminal presentation produced a combined effect size in anxious individuals that was almost twice as large as that produced by supraliminal exposure, suggesting a relatively smaller contribution of conscious processes to the task. The pattern of results is consistent with the suggestion that biases observed using the emotional Stroop task reflects relatively late, controlled processes, whereas biases revealed using the dot-probe paradigm reflects earlier attentional processes (MacLeod et al., 1986).

**Multi Stage Model of Threat Evaluation**

Based on the results of the meta analyses Bar-Haim et al. (2007) proposed that valence based bias in anxiety is a function of several cognitive processes, including preattentive, attentional and postattentive processes (Posner & Peterson, 1990). That is, individual differences in anxiety are driven by a preattentive threat detection bias, reflected in the evidence for biases with subliminal threat stimulus presentation, and by later attentional resource allocation mechanisms and top-down processes, reflected in the larger effect size for supraliminal threat stimulus presentation. Bar-Haim et al. (2007) also argue that separate contributions of conscious and unconscious processes to threat detection and evaluation in anxiety is further validated by the finding that stimulus awareness modulates biases in opposite directions in the emotional Stroop and dot-probe tasks.

Consistent with the results of the meta analyses Bar-Haim et al. (2007) proposed an integrative model (figure 10 below), which incorporates several aspects of previous models. Instead of assigning the bias to a malfunction of only one cognitive process, they propose that anxious individuals may display abnormal processing patterns at four different stages along a continuum of consciousness or in their various combinations. A preattentive threat evaluation system (PTES) preattentively evaluates stimuli in the environment. A stimulus that is tagged with a high threat value feeds forward into a resource allocation system (RAS) and triggers physiological alert state, interruption of ongoing activity, allocation of processing resources to the stimulus, and a conscious anxious state. These outcomes lead to a set of strategic processes carried out by a guided threat evaluation system (GTES). At this stage, assessment of the context of the threat
stimulus, comparison of the present threat with prior learning and memory, and assessment of the availability of coping resources take place. If the outcome of this guided threat evaluation results in a low conscious threat evaluation, a feedback process is triggered that overrides the input emanating from the PTES and relaxes the alert state imposed by the RAS. If, in contrast, the result of this guided evaluation corroborates the threat alert invoked by the PTES, a high state of anxiety is likely to proceed.

Bar-Haim et al. (2007) proposed that the cognitive processes of threat detection viewed in this way imply that high-trait anxiety or different anxiety disorders may stem from one or several of the following processes: (a) a tendency to automatically evaluate benign or slightly threatening stimuli as high threat, that is, a bias in the preattentive threat evaluation system (PTES); (b) a tendency to allocate resources even to stimuli evaluated as only mildly threatening, that is, a bias in the resource allocation system (RAS); (c) a tendency to consciously evaluate alert signals as highly threatening even when context, prior learning and available coping resources may indicate the contrary, that is, a bias in the guided threat evaluation system (GTES); (d) a deficit in the overriding mechanism, in which case even conscious understanding of the irrational aspect of the threat evaluation cannot terminate the anxious state, that is, a controlled attention or executive functioning deficit.

Additional support for this model comes from the processing bias of subject dominant concern (e.g. Dalgleish, 1995). Macleod et al. (1986) found that in the dot probe paradigm, both physical and social threat stimuli exerted an equivalent influence on anxious individuals’ distribution of attention despite the participants having either social or physical based dominant concern. In contrast Mathews and Macleod (1985) found an interaction between dominant concern and stimuli threat type (i.e. social/physical) when using the emotional Stroop task. Macleod et al. (1986) suggested that early encoding stage general bias to threat stimuli is reflected in performance of the dot probe task, but that subsequent processing of threat stimuli that is more extensive, prolonged and related to areas of particular concern is reflected in performance of the emotional Stroop task. In relation to the Bar-Haim et al. (2007) model, these findings may reflect a processing bias at the preattentive threat evaluation system (PTES) and the guided threat evaluation system (GTES) respectively.
Figure 10. A model of the cognitive mechanisms underlying threat processing (Bar-Haim et al., 2007)
Emotional Stroop Conclusions

Evidence suggests that the emotional Stroop task may involve multiple stages of attention in threat detection and evaluation. Despite Chajut et al. (2005) maintaining that the classic Stroop task taps executive processes while the emotional Stroop task taps automatic processes, the existence of a slow emotional Stroop effect (Makenna and Sharma, 2004; Waters, et al., 2003), subject dominant concern bias (Mathews and Macleod, 1985; Williams et al. 1996) and larger effects with optimally presented stimuli (Bar-Haim et al., 2007; Phaf and Kan, 2007) suggest that performance on the emotional Stroop task involves postattentive processes and therefore some form of executive control. However, it is unclear whether performance on the emotional Stroop effect assesses the conscious effort to ignore the emotional dimension of a stimulus or a difficulty to disengage from it.

Bar-Haim et al. (2007) models suggest threatening emotional stimuli automatically orient and capture attention of anxious individuals early in a continuum of consciousness through activation of a threat detection system (Bar-Haim et al., 2007). This activation reorients cognitive resources to the detection of further threat. This process reduces the ability of identifying ink colour as seen in connectionist accounts of the classic Stroop effect (Cohen et al., 1990). Such bottom up activation would require controlled attention, or the enhancement of context representations, in order to continue with the ongoing task.

Unlike the classic Stroop task, the inhibitory mechanism in emotional Stroop is unlikely to be a prepotent response inhibition as emotional words are not part of the task demand. It is more likely to involve resistance to distracter interference (Nigg, 2000). Kane, Bleckley, Conway and Engle (2001) suggests that resistance to distracter interference requires maintaining the task goal in a state of high activation in the face of a more dominant but inappropriate responses or to distracting stimuli in the environment. Prepotent response inhibition and resistance to distracter interference have been found to be highly related (Friedman & Miyake, 2004) reflecting behavioural inhibition and resistance to interference respectively (Nigg, 2000). It could be argued therefore, that the classic Stroop task most likely involves a degree of each. The classic Stroop may primarily be a measure of prepotent response inhibition due to stronger word reading pathways interfering with colour naming. However, by increasing the reliance of the task on context representations it could become primarily a measure of resistance to distracter interference. That is, maintaining the task goal in a state of high activation in the face of a more dominant but inappropriate responses. In contrast, since emotional words in an emotional Stroop task
are not part of the task response set then the task does not involve *prepotent response inhibition*. However, since word reading involves stronger processing pathways than colour naming then the emotional Stroop task measures how much the emotional word reorients cognitive resources to the processing of further threat. Essentially it is a measure of how threatening a cognitive system views a stimulus and how much it distracts resources from the ongoing task (i.e. respond to ink colour) and therefore is a measure of *resistance to distracter interference*. Theoretically, therefore, the emotional Stroop task is a measure of both emotion processing and executive functioning and response latencies to emotional word stimuli could reflect resources allocation to threat and or resource allocation to the ongoing task.

**Emotional Stroop and Multidimensional Schizophrenia/Schizotypy**

Few studies have examined the impact of emotion on attentional processes in multidimensional schizotypy using the emotional Stroop task. One recent study (Mohanty et al., 2005) found that behavioural measures of negative word emotional Stroop interference did not differ between a positive schizotypy group and a control group. Mohanty et al. (2005) limited their investigation to a positive schizotypy sample as a previous study found that patients diagnosed with schizophrenia who presented with positive symptoms displayed more interference for threat-related words on an emotional Stroop task than did patients without active psychotic symptoms (Epstein, Stern and Silbersweig, 1999 cited in Mohanty et al., 2005). In support of such a dissociation, Mohanty et al. (2008) found a non-linear relationship between positive schizotypy and negative word interference on the emotional Stroop task. The effects were isolated to the highest scoring positive schizotypy group in the upper quartile of their sample of positive schizotypy scores. Negative schizotypy was, however, unrelated to behavioural responses to positive or negative emotional Stroop stimuli.

**Conclusions**

Although elevated negative affect is associated with cognitive perceptual symptoms (positive schizotypy) (Berenbaum et al., 2006) a similar association is also found with interpersonal symptoms (negative schizotypy) and anhedonia (Blanchard et al., 1998; Gooding et al., 2002; Mathews & Barch, 2006). However, positive schizotypy display
increased attention to emotion (Berenbaum et al., 2006; Green et al., 2001; Kerns, 2005; Kerns & Berenbaum, 2000), increased emotional awareness (Berenbaum et al., 2006), decreased clarity of emotions (Kerns, 2005) and emotional Stroop interference effects with negative stimuli (Mohanty et al. 2008). In contrast, negative schizotypy is negatively associated with attention to emotion (Berenbaum et al., 2006), decreased emotionality, increased emotional confusion (Kerns, 2006) and no effect on the emotional Stroop task with positive or negatively valenced stimuli (Mohanty et al., 2008).

Berenbaum et al. (2006) suggested that reduced attention to emotion could be the cause of or effect of interpersonal difficulties. Low attention to emotion may make it difficult, or less appealing, to establish strong interpersonal ties or that interpersonal difficulties may lead individuals to stop attending to their emotions. The observation by Blanchard et al., (1998) that social anhedonia but not physical anhedonia was associated with greater trait negative effect provides evidence for the latter possibility. Negative schizotypy may be emotionally overwhelmed by negative social cues. Interpersonal difficulties might subsequently result from maladaptive strategies to ignore or inhibit attention to emotions or their cues.

Reduced attention to emotion may also influence the effectiveness of rewards and punishments in behavioural conditioning systems. Negative schizotypy groups have reduced subjective ratings of the valence of positive stimuli as they tend to rate positive stimuli as less positive than control groups (Ferguson and Katkin, 1996; Fitzgibbon and Simons, 1992; Mathews and Barch, 2006). Furthermore, a number of studies indicate that negative schizotypy and anhedonic groups are negatively related with reward responsiveness (Applegate, et al., 2009; Germans and Kring, 2000; Horan et al., 2006).

**Predictions and Hypotheses**

Mohanty et al. (2008) found a non-linear relationship between positive schizotypy and performance on the emotional Stroop task with effects being isolated to those with positive schizotypy scores in the upper quartile of the sample. It might therefore be expected that those scoring in the upper and lower quartiles of a negative schizotypy dimension might also display unique non-linear effects. The pattern of responses to positive and negative emotional cues might therefore be unique in high and low introvertive anhedonia groups.
The evidence reviewed above suggests that negative schizotypy is associated with blunted emotion processing that is characterised by reduced attention to emotion (Berenbaum et al., 2006) and decreased emotionality (Kerns, 2006). These results might account for the absence of emotional Stroop effects in negative schizotypy (Mohanty et al., 2008). High scoring introverted anhedonics in the current experiment are therefore not expected to display a processing preference for valenced emotional stimuli and not respond differently to positive and negative emotional Stroop stimuli (Hypothesis 1).

In contrast, those with none or few negative schizotypy traits attend more to their emotions (Berenbaum et al., 2006) and show heightened reward responsiveness (Applegate, et al., 2009; Germans and Kring, 2000; Horan et al., 2006). Low scoring introverted anhedonics in the current study are therefore expected to preferentially process positive valenced stimuli over negatively valenced stimuli and generate longer reaction time latencies and greater errors to positively valenced emotional Stroop stimuli than negative emotional Stroop stimuli (Hypothesis 2).

3.1.1: Experiment 3. Method

Introduction

This experiment sought to examine emotion cue processing preferences in introverted anhedonia. It used emotional Stroop task as it provides a measure of the depth at which emotional cues are processed. The paradigm has proved its usefulness through extensive use in assessing emotion cue processing in anxiety.

The experiment specifically sought to examine whether a high introverted anhedonia group ambiguously process positive and negative emotional Stroop stimuli. It also sought to examine whether the absence of introverted anhedonic traits results in a processing preference for positive than negative stimuli.

Participants

Forty eight participants were recruited into the study 83.3% of whom were female. The sample had a mean age of 23.06 years with a standard deviation of 6.59. Participant
recruitment and inclusion criteria were identical to that of experiment 1 and 2. High and low introverted anhedonia groups were recruited and defined according to age and gender normed introverted anhedonia scores equal to or within the upper and lower quartiles of the normed introverted anhedonia distribution (Mason & Claridge, 2006; see Table 5). Participants were excluded from the study if known to have colour blindness, non-corrected vision less than 20/20 or being under the influence of substances known to distort mood, perception and or attention. The demographics of the high and low introverted anhedonia groups was again not known until the end of data collection and are therefore reported in the results section.

Materials

The emotional Stroop task was programmed and presented using e-prime v.1.2 application suite. Four word categories were used: social negative, physical negative, social positive and physical positive. Word stimuli with both extreme valence ratings (i.e. positive/negative) and high arousal ratings were sourced from the ANEW list (Bradley, M.M., & Lang, P.J. 1999) and normed for category membership (i.e. social/physical; see appendix 3). Three words per category were then selected ensuring that they balanced across categories on valence (i.e. positive/negative), arousal and length (see appendix 4). The colours used in the experiment were red, green, blue and yellow. Each word was presented once with its print in each of the four colours. This yielded 48 items in total, 12 in each semantic category. An additional 12 items were constructed as practice items that consisted of four #’s (i.e. ####) presented in each of the four colours three times.

Procedure

Procedure was identical to that of the Stroop colour word experiment presented previously (see method experiment 1). Stimuli were however presented in 5 blocks. The first block contained practice items to which the participants again had to meet an 80% response accuracy criterion. The other 4 blocks contained the critical trials. A short break followed each block, which participants ended and continued with the task by pushing the response box centre button. Critical items were presented in two consecutive valence blocks (i.e. positive block/ negative block). Within these valence blocks items were further blocked by semantic category (e.g. social positive/physical positive). Valence block presentation
order was counterbalanced across two testing sessions and across participants. Within
valence block semantic category block presentation order was also counterbalanced across
participants. This meant that each participant would be presented with semantic category
blocks in one of four possible combinations (Table 2). Within semantic category block
item presentation was randomised ensuring that no colour was presented consecutively.

The experimenter observed and supervised completion of the practice block to ensure that
participants understood the demands of the task. At the first session participants had
previously completed a Stroop colour word task that lasted for approximately 2 minutes
and had the same task demands and response options of the current emotional Stroop task.
A dot probe task, lasting 8 minutes, had also been completed which used the same
emotional word stimuli employed in the current emotional Stroop task. Following testing
participants were given a full de-brief.

**Method of Analyses**

An index of valence effect was first calculated for each individual by subtracting reaction
times to negatively valenced emotional Stroop stimuli from reaction times to positively
valenced emotional Stroop stimuli (RT positive stimuli minus RT negative stimuli). A
positive value would indicate slower responses to positively valenced stimuli than
negatively valenced stimuli.

A multiple regression analysis was then conducted to account for the possible confounding
influence of other schizotypal dimensions on the valence effect. The index of valence
effect was therefore included in the regression as the dependant variable with unusual
experiences, impulsive non-conformity and cognitive disorganisation schizotypy
dimensions entered as predictors. Data were screened for outliers, which if present were
removed from the analyses. Furthermore, normality of the data was assessed and if
significant skew was present then the variable was transformed until normality was
achieved.

The error measure of valence effect (proportion of errors to positive stimuli minus
proportion of errors to negative stimuli) did not meet the testing assumptions for regression
analyses. The distribution was skewed and could not be normalised by transformations.
The distributions were also leptokurtic as most observations were around zero. The
variable was therefore recoded into three categories; those with a greater proportion of errors to positive than negative stimuli (category 1), those with no difference in errors for positive and negative stimuli (category 2) and those with a greater proportion of errors to negative than positive negative stimuli (category 3). This nominal measure of the valence effect was analysed as the dependent variable in a multinomial regression analyses with category 2 as the reference category and unusual experiences, impulsive non-conformity and cognitive disorganisation schizotypy dimensions as predicators.

Reaction time latencies and proportions of errors of the high and low introvertive anhedonia groups to positively and negatively valenced emotional Stroop stimuli were subsequently analysed. These analyses addressed the hypotheses by making two specific within groups comparisons. Responses to positive and negative emotional Stroop stimuli were compared in the high introvertive anhedonia group and the same comparison was made in the low introvertive anhedonia group. ANOVA’s make multiple within groups comparisons but they also make multiple between groups comparisons that are irrelevant to the current analyses. The use of an ANOVA in this circumstance might increase type 2 error rate. To avoid type 2 error inflation, repeated measures t-tests were used with the alpha value adjusted for two overall comparisons using the Bonferroni method.

3.1.2: Experiment 3. Results

Demographics

Mean ages and gender composition of the high and low introvertive anhedonia groups are presented in Table 13. According to the criteria outlined in the method section, 28 participants were defined as low introvertive anhedonia and 20 were defined as high. Being defined as high or low introvertive anhedonia was not associated with gender (p>.05 fishers exact test). These two groups also did not differ in age (t=0.518, df = 46, p>.05) (see table 15).
Table 15
Gender and age by high/low introvertive anhedonia

<table>
<thead>
<tr>
<th>Gender</th>
<th>Low (n=28)</th>
<th>High (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>Male</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Age (mean/SD)</td>
<td>22.6 (5.5)</td>
<td>23.7 (7.9)</td>
</tr>
</tbody>
</table>

The high introvertive anhedonia group had higher mean unusual experiences, cognitive disorganisation and impulsive non-conformity scores than the low group. These group differences were not statistically significant for the cognitive disorganisation ($t=1.766$, $df=46$, $p>.05$) and impulsive non-conformity ($t=0.729$, $df=28.015$, $p>.05$) subscale scores. However, the high introvertive anhedonia group did have significantly higher unusual experiences score ($t=2.466$, $df=46$, $p<.05$) (table 16)

Table 16
O-LIFE total scores and subscale scores by high/low introvertive anhedonia

<table>
<thead>
<tr>
<th></th>
<th>Low (n=28)</th>
<th>High (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>(SD)</td>
</tr>
<tr>
<td>Unusual Experiences</td>
<td>8.00</td>
<td>(5.86)</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>12.00</td>
<td>(4.23)</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>8.68</td>
<td>(2.78)</td>
</tr>
<tr>
<td><strong>Introvertive anhedonia</strong></td>
<td><strong>1.29</strong></td>
<td><strong>(0.76)</strong></td>
</tr>
<tr>
<td>O-LIFE Total</td>
<td>29.96</td>
<td>(8.43)</td>
</tr>
<tr>
<td></td>
<td><strong>11.55</strong></td>
<td><strong>(3.20)</strong></td>
</tr>
</tbody>
</table>

Experimental analyses

As in the first two experiments, erroneous responses, constituting 3.43% of the data set were removed from the analyses. Furthermore, long and short responses, totalling less than 1% of the data set, were also removed. These short and long responses were defined by the same criteria as in experiment 1 and 2.
Multiple Regression Analyses

Multiple regression analyses examined reaction time valence effect (positively valenced emotional Stroop stimuli minus negatively valenced emotional Stroop) as a dependant variable with schizotypy trait dimensions that were not of direct relevance to the current investigation as predictor variables. The unusual experiences and impulsive nonconformity variables had significant skew and were subjected to square root transformation. All other variables were normally distributed. The unusual experiences, impulsive nonconformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method. A significant model did not emerge (F(3,44)=0.404, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of the valence effect (see appendix 1. table A1.6 for coefficients of predictors).

Logistic Regression Analyses

A multinomial logistic regression analysis was conducted with a dependant variable that consisted of a greater proportion of errors to positive stimuli than negative stimuli as one category and a greater proportion of errors to negative stimuli than positive stimuli as another category with no difference in errors to positive than negative stimuli as the reference category. The unusual experiences, impulsive nonconformity and cognitive disorganisation schizotypy trait dimension were included as predictors. The analyses indicated that none of the schizotypy trait dimension predicted greater errors to positive than negative stimuli or greater errors to negative than positive stimuli compared to no difference in errors to positive and negative stimuli (likelihood ratio chi square(6) = 7.269, p>.05) (see appendix. 1 table A1.7 for coefficients of predictors).

Reaction Time Analyses

Figure 11 presents the reaction time means of the high and low introvertive anhedonia groups to positive and negative emotional Stroop stimuli. The high introvertive anhedonia group responded with comparable speed to positive and negative emotional Stroop stimuli. However, the low introvertive anhedonia group had a slower reaction time mean to positive than negative emotional Stroop stimuli.
The alpha level for significance was set for two comparisons at .025. Subsequently, two paired samples t-tests examining the valence reaction times for the high and low introvertive anhedonia groups (Figure 11) found that the low introvertive anhedonia group had significantly higher mean reaction times to positive than negative stimuli (t=3.604, df=27, p<.001, Cohen’s d=0.67). In contrast, the high introvertive anhedonia group did not generate significantly different reaction times to positive and negative stimuli (t=0.381, df=19, p>.025).

ANOVA Analysis of Errors

Figure 12 below presents the mean proportion of errors of the high and low introvertive anhedonia groups to positive and negative emotional Stroop conditions. Both the high and low introvertive anhedonia groups had slightly smaller percentage of errors to negative stimuli than positive stimuli. The alpha level for significance was again set for two comparisons at .025. Subsequently, two paired samples t-tests examining the valence effects found that the proportion of errors from positive and negative conditions did not differ for either the high (t=0.224, df=19, p>.025) or low (t=0.474, df=27, p>.025) introvertive anhedonia groups.
Figure 12. Mean percentage of errors of the high and low introvertive anhedonia groups to negative and positive emotional Stroop stimuli (error bars represent SE of the mean)

3.1.3: Experiment 3. Discussion

Summary

High and low introvertive anhedonia groups generated different emotional Stroop reaction time valence effects. The high introvertive anhedonia group did not generate a significant valence effect and responded with comparable speed to stimuli with a positive and negative valence, which is consistent with hypothesis 1. In contrast, the low introvertive anhedonia group produced a valence effect with slower responses to positive stimuli than negative, which supports hypothesis 2. These effects were not, however, reflected in the error data. Both the high and low introvertive anhedonia group produced a comparable percentage of errors whilst responding to positive and negative emotional Stroop stimuli.

Comment on findings

The analyses indicated that the parameters of the current emotional Stroop task detected differential processing of positive and negative stimuli. Typically, the emotional Stroop task demonstrates longer response latencies to words relating to an individual’s particular concern such as phobias (Williams et al, 1996). In this case, however, positive words produced longer response latencies than negative words. The absence of an interaction between valence and semantic category further suggest that positive physical stimuli,
which generated the longest overall reaction time mean, may have been the category driving observed effects. The absence of an interaction further suggests that a full four way distinction between valence (i.e. positive/negative) and category (i.e. physical/social) may be redundant to the aims of the study.

The effect of valence in the low introvertive anhedonia group therefore suggests that a greater amount of cognitive resources were allocated to the processing of positive than negative stimuli. As a delay in responding to emotional Stroop stimuli typically indexes an individual’s particular concern (Williams et al, 1996) then such a valence effect might be reflecting a hypersensitive appetitive pleasure system. This is consistent with a number of studies suggesting that levels of anhedonia are negatively related with self report measures of reward responsiveness (Applegate et al., 2009; Germans and Kring, 2000; Horan et al., 2006).

The absence of a valence effects in the high introvertive anhedonia group further suggests that positive or negative stimuli did not demand a different allocation of processing resources. This could reflect blunted attentional processing of emotional stimuli (Berenbaum et al., 2006; Kerns, 2006) and is somewhat consistent with previous studies that fail to observe emotional Stroop effects in negative schizotypy (Mohanty et al., 2005; Mohanty et al., 2008). Specifically, the absence of a valence effect in the high introvertive anhedonia group for the preferential processing of positive stimuli might reflect the blunting of an appetitive pleasure or reward system. This is again consistent with a number of self report studies indicating that anhedonia is negatively related with reward responsiveness (Applegate, et al., 2009; Germans and Kring, 2000; Horan et al., 2006).

Furthermore, the absence of a valence effect for the preferential processing of negative stimuli in the high introvertive anhedonia group further suggest that they are not characterised by increased threat processing that is typically seen in high anxious groups (e.g. Williams et al., 1996). Elevated negative effect seen in negative schizotypy (e.g. Berenbaum et al., 2006; Blanchard et al., 1998) may therefore result from a reduction in the processing of positive stimuli rather than an increase in the processing of negative stimuli.

The current experiment did not use a neutral condition and its absence prevents firm conclusions. The current valence effect establishes that positive or negative stimuli are processed differently. However, it does not establish whether there are processing biases to either positive or negative stimuli. Processing preferences may not be observed when
compared to a neutral condition. This shortcoming will be the focus of the next experiment that will use a dot probe paradigm to measure the competition for attentional resources between emotionally valenced stimuli and neutral stimuli.

**Relate findings to past research**

The valence effect in the low introvertive anhedonia group suggesting that a different amount of processing resources was allocated to positive stimuli could be reflecting similar cognitive processes that underlie the processing of threat cues of a particular concern. Bar-Haim, et al.’s (2007) multi stage model of threat evaluation could be adapted to account for the preferential processing of positive stimuli observed in the low introvertive anhedonia group. The positive word cues may be seen as activating a preattentive emotion evaluation system, referred to in Bar-Haim, et al.’s (2007) model as a preattentive threat evaluation system (PTES). Activation here feeds into a resource allocation system (RAS) interrupting ongoing activity, orienting the cognitive system to the cue and heightening physiological activity. This stage could be seen as the activation of an appetitive pleasure system in response to the preattentive processing of positive stimuli. A guided emotional cue evaluation system (GECES), reflecting the guided threat evaluation system (GTES) in Bar-Haim, et al.’s (2007) model, then consciously processes the cue thus reflecting a set of strategic processes that compares the cue with memory and assesses the context of its presentation. In relation to the processing of emotional cues in an emotional Stroop task, the GECES may assess them as irrelevant to the current task and a goal engagement system, such as that in Bar-Haim, et al.’s (2007) model, may consequently apply top down cognitive control to respond to print colour. Bar-Haim, et al.’s (2007) model does not however offer insight into whether delayed responding to emotional Stroop stimuli reflects effortful avoidance of processing emotional content (De Ruiter and Biosschot, 1994) or a difficulty in disengaging attention from emotionally salient stimuli (e.g. Waters et al., 2003).

If it is assumed that the results of the low introvertive anhedonia represent ‘normal’ emotion cue processing then the processing of positive stimuli in the high introvertive group could reflect either a less active preattentive emotion evaluation system or deficits in the resource allocation system. The valence processing of the word cues may not have occurred at an early stage of stimulus processing. The absence of a valence effect in the high introvertive anhedonia group might therefore have resulted from the absence of
bottom up stimulus driven processing of positive stimuli. However, that absence of a neutral category in the current experiment again prevents definitive conclusion that the high introvertive anhedonia group have failures in preattentive emotion processing system.

The low introvertive anhedonia group reflects individuals on the polar extreme to individuals scoring high on introvertive anhedonia and their emotion cue processing may be equally though differentially disabled. For example, if it is assumed that the low introvertive anhedonia group allocated a greater amount of processing resources to positive than negative stimuli then this could result in maladaptive risk taking behaviours. The processing of threats might provide an adaptive evolutionary advantage that increases the chances of survival. However, when such processing becomes extreme it becomes maladaptive and can results in acute and chronic anxiety. The preference for the processing of positive stimuli might also provide an adaptive evolutionary advantage increasing optimism in times of despair and in calculated risk taking behaviour such as hunting and the exploration of new uncharted territory. When such processing becomes extreme it might also become maladaptive possibly resulting in dangerous risk taking behaviour. However, before this possibility can be explored further, future experiments would first need to determine the precise nature of emotion cue processing in the low introvertive anhedonia group.

Methodological Problems and Limitations of the Current study

The most apparent methodological confound of the current study, is the absence of a neutral condition. This has reduced the ability to interpret results and prevented definitive conclusions regarding the nature of positive and negative emotion cue processing of the low introvertive anhedonia group and the absence of emotion cue processing difference in the high introvertive anhedonia group. This limitation will be addressed in the next experiment using a dot probe task.

As in experiment 1 and 2, the high and low introvertive anhedonia groups were not only significantly different on levels of introvertive anhedonia but also on levels of unusual experiences, the O-LIFE’s positive schizotypy dimension. Observed effects cannot therefore be attributed solely to levels of introvertive anhedonia or negative schizotypy. However, multiple and logistic regression analyses indicate that reaction time and error measures of the valence effect were unrelated to unusual experiences, cognitive
disorganisation and impulsive non-conformity schizotypy dimensions and global schizotypy scores.

Conclusion

The study explored patterns of valence effect with emotional Stroop stimuli in two groups scoring high and low on the O-LIFE introvertive anhedonia dimension. The low introvertive anhedonia group displayed slower reaction times to positive stimuli compared to negative stimuli while the high introvertive anhedonia group did not display a response difference to positive and negative stimuli.

The results of the low introvertive anhedonia group are consistent with previous studies that use self-report measures indicating that negative schizotypy and anhedonia have increased reward responsiveness. Furthermore, the results of the high introvertive anhedonia group suggests blunted processing of emotional stimuli and is consistent with previous studies that fail to find emotional Stroop effects in negative schizotypy (Applegate, et al., 2009). Results of the high introvertive anhedonia group further suggest that negative schizotypy is not associated with increase threat processing but perhaps with the absence of the preferential processing of positive stimuli. The study cannot, however, draw definitive conclusions regarding the nature emotion cue processing in introvertive anhedonia due to the absence of a neutral condition.

3.2: Experiment 4. Dot Probe

The preceding experiment using the emotional Stroop task suggests that introvertive anhedonics have blunted processing of emotional cues as they did not respond differently to negative or positive emotional cues. In contrast, the experiment did find evidence suggesting that the low introvertive anhedonia group preferentially processed positively valenced emotion cues over negative cues. However, the absence of a neutral condition prevented definitive conclusions. Furthermore, it is also unclear whether effects with emotional Stroop stimuli result from the effortful avoidance of processing emotional content (De Ruiter and Biosschot, 1994) or from a difficulty in disengaging attentional resources from emotionally salient stimuli (e.g. Waters et al., 2003). The next experiment
addresses these issue by using a modified dot probe paradigm that used emotion cue stimuli and neutral stimuli to provide a measure of attentional orientation toward emotional stimuli and a measure of disengagement from emotional stimuli.

The dot probe paradigm

The dot probe paradigm (Macleod et al., 1986) typically involves the simultaneous presentation of threat and neutral stimuli. These stimuli are then replaced by a dot probe (e.g. *) in the location of either the threat or neutral stimuli (see Figure 13). The task is thought to reflect the distribution of participants’ attention. Reaction times to dot probes are typically faster when they are presented in the location of the participants attention. Attentional bias towards threat is therefore revealed when participants respond more quickly to probes that replace threat related stimuli rather than probes that replace neutral stimuli. Macleod et al. (1986), for example, reported such biases in a high anxiety group. In contrast, the low anxious individuals respond more quickly to dot probes when they appeared in a location other than that of threat stimuli. As such, Macleod et al., (1986) hypothesised that high anxious individuals tend to orient attention towards threatening stimuli while low anxious individual shift attention away from threatening stimuli. However, faster reaction times to dot probes that replace threat stimuli may also result from a difficulty to disengage attention from the threat location (Derryberry & Reed, 2002). Biases of high anxious individuals to threat locations may therefore reflect either faster engagement with threat stimuli or an increased difficulty to disengage attention from them.

Figure 13. The dot probe task. Threat and neutral stimuli are presented simultaneously and are then replaced by dot probe (*) in the location of either the threat or neutral stimuli. Participants are required to respond to the location of the dot probe (*) as quickly and as accurately as they can.
To differentiate between these possibilities Koster, Crombez, Verschuere and De Houwer (2004) modified the dot probe paradigm by including in their experiment trials of only neutral stimuli. These neutral trials present two neutral stimuli (i.e. neutral/neutral) rather than one neutral stimulus and one threat stimulus (i.e. threat/neutral). Orientation bias towards threat would still be indexed by faster responses to dots replacing the location of threat stimuli compared to dots replacing the location of neutral stimuli. However, difficulty in disengaging attention from threat was indexed by slower reaction time response to dot probes that replaced neutral stimuli when the threat stimuli was in the other location (i.e. dotNeutral/threat). The crucial manipulation was therefore whether the dot probe replaced threat or neutral stimuli on threat/neutral trials (see Figure 14 below).

<table>
<thead>
<tr>
<th>Orientation trials</th>
<th>Neutral trials</th>
<th>Disengage trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threat Neutral</td>
<td>Neutral Neutral</td>
<td>Threat Neutral</td>
</tr>
</tbody>
</table>

Faster RT to dot probe compared to RT to dot probe on neutral trials indicate an orientation bias

Slower RT to dot probe compared to RT to dot probe on neutral trials indicate a disengagement bias

Figure 14. Orientation and disengagement trials in the modified dot probe task (Koster et al. 2004). Note. Orientation trials present the dot probe in the location where the threat stimuli was presented. Disengagement trials present the dot probe in the location where the threat stimuli was not presented. Neutral trials do not include threat stimuli and the dot probe is presented in the location where one of the neutral stimuli was presented.

Using measure of attentional orientation and attentional disengagement, Koster et al. (2004) found no evidence of enhanced orientation to threat but participants had significant difficulty in disengaging attention from threatening stimuli (see also Salemink, van den Hout & Kindt, 2007 for replication). The results suggest that the dot probe paradigm measures only the disengagement component of attention.
Fox, Russo, Bowles and Dutton (2001) critiqued the dot probe paradigm for presenting stimuli in locations that are both task relevant and argued that an obvious strategy for participants to adopt would be to attend to both locations, or rapidly shift attention between the two locations. Critical stimuli would therefore never appear in an unattended location. A further criticism of the dot probe paradigm forwarded by Fox et al. (2001) was the relatively long stimulus presentation time (i.e. 500msec), which was argued to further increase attentive processing at both locations. These factors increased difficulty in determining whether threat stimuli attract attention or whether once detected they increase dwell time at that location. To address these issues, Fox et al. (2001) modified the exogenous cueing paradigm (Posner, Inoff, Fredrich & Cohen, 1987) and developed an emotional spatial cuing paradigm.

The original exogenous cueing paradigm presents a cue (e.g. flashing light) in one of two locations. The cue is followed by the presentation of a target (e.g. a square) at the cued location on 80% of trials, which are called valid cue trials. In the remaining 20% of trial the target appears in the opposite location to the cue, which are called invalid cue trials. Typically, reaction times to the location of targets are faster on valid cue trials than invalid cue trials. It is thought that the exogenous cue (e.g. flashing light) induces a covert orientation of attention to the cued location leading to faster reaction times on valid trials and slower reaction times on invalid trials. Reaction time speeding on valid cue trials is attributed to the benefits of attentional engagement with the cued location, while slowing on invalidly cued trials has been associated with the costs of disengaging attention from the cued location. Fox et al.’s (2001) modification involved replacing cues (e.g. flashing light) with threat related and neutral stimuli. In this emotional spatial cuing paradigm a threat related attentional bias is indexed by greater validity effects, that is faster responses to valid cue trials than invalid cue trials, when the cue is a threat related stimulus than when it is a neutral stimulus. Furthermore, faster responses on valid cue trials when the cue is threat related compared to a neutral cue indicates that the attentional bias occurs at the initial stages of attentional orientation. In contrast, slower responses on invalids cue trials when the cue is threat related compared to neutral cue, reflects a difficulty in disengaging attention from threat after attention has been engaged. In support, Fox et al. (2001) found that threat related cue words slowed reaction to targets on invalid trials compared to positive or neutral cue word stimuli. This suggests that the presentation of threat related words increased dwell time at that location thereby disrupting localisation of a target appearing in another location. These findings provide support for a disengagement
account of attentional bias to threat and the results of both Koster et al. (2004) and Salemink et al. (2007) using the dot probe paradigm.

Fox et al. (2001) further criticised the dot probe paradigm for presenting two cue stimuli in locations that are both task relevant. However, Bar-Haim et al. (2007) suggested that stimulus competition might be an important prerequisite for the detection of threat related attention bias. The short stimulus presentation (100msec) used by Fox et al. (2001) on valid trials (i.e. where the target is presented in the same location as the cue) of the exogenous cueing paradigm may enable relatively automatic evaluation of stimuli at initial stages of attention. However, without stimulus competition the stimulus’ role as a cue to target location may be primary. Whether the cue is neutral or threat related they are equally predictive of target location and are likely to produce similar reaction time latencies. On the other hand, once attention is captured by a stimulus on invalid trials (i.e. where the target is presented in a different location to the cue) a threat bias may present due to the disengagement component. The dot probe paradigm may therefore provide a more sensitive measure of threat processing biases than the emotional exogenous cueing paradigm as it presents two stimuli in the visual field that compete for attention. A further difference between the dot probe and emotional cueing paradigm is that cue stimuli in the dot probe task are completely task irrelevant whereas in the emotional spatial cueing paradigm participants are instructed to attend to the cue through validity instructions.

The dot probe paradigm seems to have more similarities with the emotional Stroop task than with the emotional spatial cueing paradigm. Like the dot probe paradigm, the emotional Stroop task involves a degree of stimulus competition (i.e. word vs. ink colour). Furthermore, unlike the emotional spatial cueing paradigm, word stimuli in both the dot probe paradigm and emotional Stroop task are completely task irrelevant. However, the dot probe paradigm places no requirements on participants to process word stimuli while the emotional Stroop require that the word stimuli be actively ignored. Stimuli in the dot probe paradigm compete for processing resources (emotional word vs. neutral word) but there is no interference during response. The dependent measure (i.e. reaction time to dot probe) appears not to be a product of competition but seems to assess the consequence of competition. In contrast, the reaction time response to emotional Stroop stimuli measure processes involved in both naming ink colour and those involved in ignoring word stimuli. The delay in reaction time is the result of the semantic content of word stimuli competing for attentional resources with colour naming. Therefore, effects of emotional Stroop stimuli are an additive measure of the relative salience of word stimuli to a specific
participant and also the relative strength of their executive processes to ignore the word and respond to ink colour. Possible differences between the high and low introvertive anhedonia groups in the processes involved in executive control (see experiment 1 and 2) make interpreting between group’s differences in the emotional Stroop task problematic. In this case, the dot probe paradigm is advantageous over the emotional Stroop task in assessing the cause of emotional cue processing preferences. Response to the dot probe seems to not involve executive processes in response competition but is a measure of the allocation of attentional resources as a consequence of stimulus completion.

Conclusions

Both Koster et al. (2004) and Salemink et al. (2007) found no evidence for attentional orientation effects using the modified dot probe task. Furthermore, Fox et al. (2001) found no attentional orientation effects with an emotional exogenous cue paradigm. However, all these studies report attentional disengagement effects. This suggests that the dot probe task measures ‘carry over effects’ like the slow process in the emotional Stroop task that operates between trials. However, unlike the emotional Stroop task where during responses colour naming processes compete with word reading process, there is no conflict in the dot probe task whilst actually responding to the dot. Conflict is carried over from the presentation of word stimuli. This would provide an interpretation of attentional preferences to valenced stimuli based on difficulties in disengaging attention from stimuli and not an interpretation of attentional preferences based on orientation toward valenced stimuli.

The current experiment therefore had three main aims. Firstly, it aimed to provide supporting evidence for the valence effects reported in the emotional Stroop experiment (experiment 3) by measuring resource allocation to processing of valenced stimuli in high and low introvertive anhedonia groups. Secondly, the experiment intended to address a fundamental flaw of experiment 3 be including trials with only neutral stimuli to provide a baseline from which to assess biases to valenced stimuli. Thirdly, it aimed to provide supporting evidence for the validity of Koster et al.’s (2004) modification of the dot probe paradigm. Orientation and disengagement effects will be measured. However, it is not expected that effects will present from the measure of orientation and all hypothesised effects will be isolated to the measure of disengagement.
Predictions and hypotheses

There is currently no evidence for the presence of orientation effects using the dot probe paradigm (Koster et al., 2004, Salemink et al., 2007). The current experiment is therefore not expecting to observe any orientation effects in either the high or low introvertive anhedonia groups (Hypothesis 1).

All effects are likely to be isolated to the disengagement index. High negative schizotypy groups appear to have blunted emotion processing. Negative schizotypy is associated with reduced attention emotions (Berenbaum et al., 2006), decreased emotionality (Kerns, 2006) and the absence of emotional Stroop effects (Mohanty et al., 2008). Furthermore a high scoring introvertive anhedonia group in experiment 3 of the current thesis did not respond differently to positive and negative emotional Stroop stimuli. The high scoring introvertive anhedonia group in the current experiment is therefore not expected to display disengagement effects with either positive or negative stimuli (Hypothesis 2).

In contrast, those with none or few negative schizotypal traits attend more to their emotions (Berenbaum et al., 2006) and show heightened reward responsiveness (Applegate, et al., 2009; Germans and Kring, 2000; Horan et al., 2006). Furthermore, the low introvertive anhedonia group in the previous experiment displayed slower responses to positive rather than negative emotional Stroop stimuli. The low scoring introvertive anhedonia group in the current experiment is therefore expected to display disengagement effects with positively valenced stimuli but not negatively valenced stimuli (Hypothesis 3).

3.2.1: Experiment 4. Method

Introduction

The experiment aimed to measure differences between high and low introvertive anhedonia groups in attentional disengagement from positively and negatively valenced emotional cues (i.e. attentional dwell to emotional cues). It also measured attentional orientation to provide some supporting evidence for the validity of Koster et al’s (2004) modifications to the dot probe paradigm. Two stimulus presentation times were used
(150ms and 500ms) that approximated event related potential peaks, identified by Li, Zinbarg and Paller (2007) that suggested the involvement of both early automated processes (i.e. stimulus driven) and later more conscious processing of threat cues.

**Participants**

Forty seven participants were recruited into the study, 83% of who were female. The sample had a mean age of 22.91 years with a standard deviation of 6.58. Participant recruitment procedures were again identical to those in the previous three experiments. Low and high introvertive anhedonia groups were recruited and defined according to age and gender norms equal to or within upper and lower quartiles score of a normed introvertive anhedonia distribution (Mason and Claridge, 2006, see Table 5). Exclusion criteria included, non-corrected vision less than 20/20 and being under the influence of substances known to distort mood, perception and or attention. The size and basic demographics of the high and low introvertive anhedonia groups (i.e. gender and age) were not known until the end of data collection and are therefore reported in the results section.

**Materials**

The dot probe task was programmed and presented using e-prime v.1.2 application suite. Four semantic emotional word categories were used; social negative, physical negative, social positive, physical positive, and a fifth neutral category. Three words per category were sourced from the ANEW list (Bradley & Lang, 1999), normed for category membership (appendix 3) and balanced across categories on valence (i.e. positive/negative) arousal (high/low) and length (appendix 4). An additional three neutral words were also selected from the ANEW list as control items for the neutral condition (appendix 4).

The three words from each semantic category were paired with each neutral word once thus yielding 9 word pairs per category. Each of these word pairs was then presented once with the emotional word above the centre fixation and once with the emotional word below the centre fixation. Additionally, each of these word pairs with the emotional words appearing above and below the centre fixation were presented once with the dot probe replacing the emotional word (i.e. congruent condition) and once with the dot probe replacing the neutral word (i.e. incongruent condition) (see table 17). This yielded four
conditions over 36 trials for each of the four semantic word categories (i.e. social negative, physical negative, social positive, physical positive). A fifth category was also generated which consisted of the three neutral words paired with the three neutral control words. In total, 180 trials were generated which were divided equally over 9 blocks. Each block contained one trial from each of the four conditions from each of the five word semantic categories. A tenth block of 12 practice items consisted of probes that replaced the words ‘top’ and ‘bottom’.

Table 17
Dot probe conditions

<table>
<thead>
<tr>
<th>Emotional word</th>
<th>TOP</th>
<th>BOTTOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOP</td>
<td>Congruent</td>
<td>Incongruent</td>
</tr>
<tr>
<td>BOTTOM</td>
<td>Incongruent</td>
<td>Congruent</td>
</tr>
</tbody>
</table>

Procedure

The experimenter observed and supervised the completion of practice trials to ensure that the demands of the task had been understood. Participants subsequently completed critical trials alone in an experimental testing booth. They were asked to sit at a comfortable distance, approximately 1 metre, from the computer screen. A fixation point (+) was presented at the centre of a blank screen and participants were asked to ensure that it was horizontal with their eye level. The chair or, in extreme cases, the monitor could be adjusted to ensure that this criterion was met. Two instruction pages were then presented which introduced and presented the requirements of the task. These instructions were also relayed to the participants verbally.

Participants were asked to respond to the location of a small dot, which appeared above or below the central fixation by selecting response box button 1 for a dot appearing below the central fixation and response box button 5 for a dot appearing above the central fixation. The response box was turned horizontally so that response box button 1 was closest to the participant. Participants were instructed to respond as quickly and as accurately as they could thereby placing an emphasis on both response speed and accuracy.
Participants initiated the experiment by pushing the centre button on the response box. Each trial began with a fixation point (+) presented for 500ms. This was immediately replaced (i.e. one refresh rate of the monitor) by the cue stimuli, which was presented for 150ms or 500ms depending on the stimulus presentation block condition. At their offset, the dot probe (*) was presented until a response was made or until 2000ms elapsed at which point a ‘no response’ was recorded. At its offset, a further fixation point (+) was displayed for 1500ms. Continuous presentation of trials therefore provided a consistent inter trial interval of 2000ms and a maximum trial length of 4000ms.

Stimuli were presented in 10 blocks. A short break followed each block, which participants ended and continued with the task by pushing the response box centre button. The first block contained practice items to which the participants had to achieve 80% response accuracy. The practice block was repeated until this criterion was met. Each of the remaining 9 blocks contained the 36 randomly presented critical trials. These 9 blocks were, however, divided between two stimulus presentation times (i.e.150ms and 500ms). Some participants therefore completed five 150ms presentation time blocks and four 500ms presentation time blocks while others completed four 150ms blocks and five 500ms blocks. The first block was randomly selected and subsequent presentation of blocks with different stimulus presentation times were presented in a counterbalanced and random order.

The experimenter observed and supervised completion of the practice block to ensure that participants understood the demands of the task. Participant were recruited as part of a larger study and completed the dot probe task after completing a Stroop colour word task (experiment 1 of the current thesis) that lasted for approximately 2 minutes and an emotional Stroop task (experiment 3 of the current thesis) that also lasted for approximately 2 minutes. Following testing participants were given a full de-brief.

**Method of Analyses**

Given that no valence by semantic category interactions were observed in the emotional Stroop experiment then reaction time responses in the current experiment for stimuli from different semantic categories but of the same valence were amalgamated. Furthermore, to simplify the analyses, reaction times from the two presentation times (150 and 500ms) was also amalgamated. All analyses focused on reaction time differences between neutral trials.
and congruent orientation trials (where the dot replaced the location of the emotional word) and neutral trials and incongruent disengagement trials (where the dot replaced the location of the neutral word).

Multiple regression analyses were first conducted to examine the possible influences of other schizotypy trait dimensions that were not of direct relevance to the current investigation on measures or orientation and disengagement with positively and negatively valenced stimuli. Data were screened for outliers, which if present were removed from the analyses. Furthermore, normality of the data was assessed and if significant skew was present then the variable was transformed until normality was achieved. The indices of attentional orientation and disengagement were calculated for each participant as described below.

A measure of **attentional orientation** was calculated for each participant by subtracting their mean reaction times to congruent trials, where the dot probe replaced an emotional stimulus, from their reaction times to neutral trials (i.e. mean RT \[dot\text{Neutral, Neutral}\] minus mean RT \[dot\text{Emotional, Neutral}\]) (see table 18). A positive orientation score indicates faster reaction time responses to dot probes that appear in the same location that emotional stimuli were presented when the other stimulus was neutral (see figure 13).

Table 18. Design and analyses of the dot probe experiment

<table>
<thead>
<tr>
<th>Between groups comparisons</th>
<th>Stimulus presentation</th>
<th>Outcome measure - RT (attentional orientation and disengagement)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150ms</td>
<td>Orient [dot\text{Neutral, Neutral _ minus}] [dot\text{Emotional, Neutral _ minus}] Disengage [dot\text{Neutral, Neutral}] [dot\text{Neutral, Emotional _ minus}]</td>
</tr>
</tbody>
</table>
A measure of **attentional disengagement** was also calculated by subtracting the mean reaction times to neutral trials from the mean reaction times to incongruent trials, where the dot replaced a neutral item in the presence of an emotional item (i.e. mean RT \[\text{dot Neutral, Emotional} \] minus mean RT \[\text{dot Neutral, Neutral}\]) (see table 18). A positive disengagement score indicates slower reaction time responses to dot probes that appear in the same location that neutral stimuli were presented when the other stimulus was emotional (see figure 13).

Reaction time latencies of the high and low introvertive anhedonia groups were subsequently analysed. These analyses were interested in specifically addressing the hypotheses by examining whether orientation and disengagement indices with positively and negatively valenced stimuli were significant in the high and low introvertive anhedonia groups. ANOVA’s make multiple within groups comparisons but they also make multiple between groups comparisons that are irrelevant to the current analyses. The use of an ANOVA in this circumstance might increase type 2 error rate. To avoid type 2 error inflation, repeated measure t-tests were used. Adjusting the alpha values for significance is not usually considered necessary when contrasts are planned and specific. Furthermore, as hypothesis 1 is predicting no effects with orientation trials then adjusting for multiple comparisons might have the opposite effect and increase type 1 error. However, because eight overall comparisons were being made then some adjustment for increase in type 1 error seemed prudent. Both orientation and disengagement indices were generated from independent observations and these observations in the high and low introvertive anhedonia groups were also independent. Alpha was therefore only adjusted for the two comparisons made within the high and low introvertive anhedonia group for each attentional effect. For example, for the high introvertive anhedonia group, orientation with positive valenced trials and orientation with negative valenced trials were the two within groups comparisons for the orientation indices while disengagement with positive valenced trials and disengagement with negative valenced trials were the two within groups comparisons for the disengagement indices. The adjustments to alpha value were made using the Bonferroni method.
3.2.2: Experiment 4. Results

Demographics

Mean ages and gender composition of the high and low introvertive anhedonia groups are presented in table 19. According to the criteria outlined in the method section, 27 participants were defined as low introvertive anhedonia and 20 were defined as high. Being defined as high or low introvertive anhedonia was not associated with gender (p>.05 fishers exact test). These two groups also did not differ in age (t=0.655, df = 45, p>.05) (see table 19).

<table>
<thead>
<tr>
<th>Gender</th>
<th>Low (n=27)</th>
<th>High (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>Male</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Age (mean/SD)</td>
<td>22.4 (5.5)</td>
<td>23.7 (7.9)</td>
</tr>
</tbody>
</table>

The high introvertive anhedonia group had higher mean unusual experiences, cognitive disorganisation, impulsive nonconformity and O-LIFE total score than the low group. These group differences were not statistically significant for the cognitive disorganisation (t=1.648, df=45, p>.05) and impulsive nonconformity (t=0.643, df=28.301, p>.05) subscale scores. However, the high introvertive anhedonia group did have significantly higher unusual experiences scores (t=2.225, df=45, p<.05) (see table 20)

<table>
<thead>
<tr>
<th></th>
<th>Low (n=27)</th>
<th>High (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>8.11 (5.94)</td>
<td>12.45 (7.42)</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>12.15 (4.24)</td>
<td>14.65 (6.18)</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>8.78 (2.78)</td>
<td>9.55 (4.81)</td>
</tr>
<tr>
<td><strong>Introvertive anhedonia</strong></td>
<td><strong>1.30 (0.78)</strong></td>
<td><strong>11.55 (3.20)</strong></td>
</tr>
<tr>
<td>O-LIFE Total</td>
<td>30.33 (8.36)</td>
<td>48.20 (15.11)</td>
</tr>
</tbody>
</table>
Experimental Analyses

As in the previous experiments of this thesis, erroneous responses, consisting of 0.92% of the current data set, were removed from the analyses. Similarly, potentially spurious short and long reaction time responses that constituted a further 1.78% of the data were also removed.

Multiple Regression Analyses

Four multiple regression analyses were conducted to examine the possible influences of other schizotypy trait dimensions that were not of direct relevance to the current investigation on measures or orientation and disengagement with positively and negatively valenced stimuli.

Orientation To Positive Stimuli

The first multiple regression analyses included the index of attentional orientation with positively valenced stimuli (RT [\text{dotNeutral, Neutral}] \text{ minus mean RT } [\text{dotPositive, Neutral}]) as the dependant variable with schizotypy trait dimensions unusual experiences, impulsive nonconformity and cognitive disorganisation as predictor variables. The index of orientation with positive stimuli had severe skew and was therefore subjected to an inverse transformation. This variable also had one outlying case, which was removed from the analyses. The unusual experiences variable also had mild skew and was subjected to a square root transformation. All other variables appeared to be normally distributed

The unusual experiences, impulsive nonconformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method. A significant model did not emerge (F(3,42)=0.665, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of attentional orientation with positively valenced stimuli (see appendix 1. table A1.8 for coefficients of predictors).
Orientation To Negative Stimuli

The second multiple regression analyses included the index of attentional orientation effects with negatively valenced stimuli (RT \([\text{Neutral, Neutral}] - \text{mean RT [Negative, Neutral]}\)) as the dependant variable with schizotypy trait dimensions unusual experiences, impulsive nonconformity and cognitive disorganisation as predictor variables. The index of orientation with positive stimuli had two outlying cases, which were removed from the analyses. Furthermore, the unusual experiences variable had mild skew and was subjected to a square root transformation. All other variables appeared to be normally distributed.

The unusual experiences, impulsive nonconformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method. A significant model did not emerge (\(F(3,41)=0.489, p>.05\)) indicating that none of the included schizotypal dimensions were significant predictors of attentional orientation with negatively valenced stimuli (see appendix.1 table A1.9 for coefficients of predictors).

Disengagement From Positive Stimuli

The third multiple regression analyses included the index of attentional disengagement effects with positively stimuli  (RT \([\text{Neutral, Positive}] - \text{mean RT [Neutral, Neutral]}\)) as the dependant variable with schizotypy trait dimensions unusual experiences, impulsive nonconformity and cognitive disorganisation as predictor variables. The index of disengagement with positive stimuli had three outlying cases, which were removed from the analyses. Furthermore, the unusual experiences variable had mild skew and was subjected to a square root transformation. All other variables appeared to be normally distributed.

The unusual experiences, impulsive nonconformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method. A significant model did not emerge (\(F(3,40)=1.154, p>.05\)) indicating that non of the included schizotypal dimensions were significant predictors of attentional disengagement with positively valenced stimuli (see appendix.1 table A1.10 for coefficients of predictors).
**Disengagement From Negative Stimuli**

The fourth multiple regression analyses included the index of attentional disengagement with negatively valenced stimuli (RT [dotNeutral, **Negative**] minus mean RT [dotNeutral, Neutral]) as the dependant variable with schizotypy trait dimensions unusual experiences, impulsive nonconformity and cognitive disorganisation as predictor variables. The index of disengagement with negative stimuli had one outlying case, which was removed from the analyses. Furthermore, the unusual experiences variable had mild skew and was subjected to a square root transformation. All other variables appeared to be normally distributed.

The unusual experiences, impulsive nonconformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method. A significant model did not emerge (F(3, 42)=1.438, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of the valence effect (see appendix.1 table A1.11 for coefficients of predictors).

**Analyses of High and Low Introvertive Anhedonic Groups**

Between groups analyses examined reaction time differences between neutral trials and orientation trials, where the dot probe appears in the location that was congruent with the emotional stimuli, and neutral trials and disengagement trials, where the dot probe appears in the location that was incongruent with the emotional stimuli. Table 21 below displays the mean reaction times of the high and low introvertive anhedonia groups to neutral trials, positively and negatively valenced orientation trials (congruent trials) and positively and negatively valenced disengagement trials.

The high introvertive anhedonia group had comparable reaction times for neutral trials and positively and negatively valenced orientation trials. However, compared to neutral trials, they had slightly faster mean reaction times to positively and negatively valenced disengagement trials. The low introvertive anhedonia group displayed a different pattern of results that appeared to be related to valence. They generated comparable reaction times for neutral trials and negatively valenced orientation and disengagement trials. However, the low introvertive anhedonia group were, on average, slower in responding to positively valenced orientation and disengagement trials than neutral trials.
Table 21
Low and high introvertive anhedonia groups mean reaction times in milliseconds (and standard errors of the mean) to (a) neutral dot probe trials, (b) positive and negative orientation trials and (c) positive and negative disengagement trials

<table>
<thead>
<tr>
<th></th>
<th>Low (n=27)</th>
<th>High (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SE)</td>
<td>Mean (SE)</td>
</tr>
<tr>
<td>(a) Neutral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$dot_{Neutral}$-Neutral</td>
<td>398 (7)</td>
<td>408 (9)</td>
</tr>
<tr>
<td>(b) Orientation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$dot_{Positive}$-Neutral (congruent)</td>
<td>402 (7)</td>
<td>408 (10)</td>
</tr>
<tr>
<td>$dot_{Negative}$-Neutral (congruent)</td>
<td>399 (7)</td>
<td>408 (9)</td>
</tr>
<tr>
<td>(c) Disengagement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive-$dot_{Neutral}$ (incongruent)</td>
<td>406 (8)</td>
<td>407 (9)</td>
</tr>
<tr>
<td>Negative-$dot_{Neutral}$ (incongruent)</td>
<td>398 (7)</td>
<td>407 (9)</td>
</tr>
</tbody>
</table>

These orientation and disengagement indices for the high and low introvertive anhedonia groups are presented graphically below. Analyses of these indices used paired samples t-tests to compare the neutral condition with congruent and incongruent valenced trials and Bonferroni adjustments made for multiple comparisons.

**Orientation effects**

Figure 15 below presents the orientation indices with negatively valenced stimuli ($[\dot{\text{Neutral}}, \text{Neutral}]$ minus $[\dot{\text{Negative}}, \text{Neutral}]$) and the orientation indices with positively valenced stimuli ($[\dot{\text{Neutral}}, \text{Neutral}]$ minus $[\dot{\text{Positive}}, \text{Neutral}]$) for the high and low introvertive anhedonia groups. Orientation effects were examined in the high and low introvertive anhedonia groups using four paired samples t-tests. The alpha level for significance was adjusted for the two within group comparisons and set at .025.

Comparing mean reaction times from $[\dot{\text{Neutral}}, \text{Neutral}]$ trials with those from $[\dot{\text{Negative}}, \text{Neutral}]$ trials found no significant orientation effects with negatively valenced stimuli in either the high ($t=0.59$ df=19, p>.025) or low ($t=-0.716$, df 26, p>.025) introvertive anhedonia groups (see figure 15).
A similar analysis for trials that contained positive stimuli [Neutral, Neutral vs. Positive, Neutral] also revealed no significant orientation effects with positively valenced stimuli in the low (t=-2.311, df=26, p>.025) or high introvertive anhedonia groups (t=-0.66, df=19, p>.025) (see figure 15).

Disengagement effects

Figure 16 below presents the disengagement indices with negative stimuli ([Neutral, Negative] minus [Neutral, Neutral]) and the disengagement indices with positive stimuli ([Neutral, Positive] minus [Neutral, Neutral]) for the high and low introvertive anhedonia groups. Disengagement effects were then examined in the high and low introvertive anhedonia groups using four paired samples t-tests. The alpha level for significance was adjusted for the two within group comparisons and set at .025.

Comparing mean reaction times from [Negative, Neutral] trials with those from [Neutral, Neutral] trials found no significant disengagement effect with negatively valenced stimuli in either the high (t=-0.558, df=19, p>.025) or low (t=-0.075, df=26, p>.025) introvertive anhedonia groups (see figure 16)
A similar analysis for trials that contained positive stimuli [Positive, dotNeutral vs. dotNeutral, Neutral] revealed a significant disengagement effect with positively valenced stimuli in the low introvertive anhedonia group (t=2.375, df=26, p<.025, one tailed, Cohen’s d=0.21) but not in the high introvertive anhedonia group (t=-0.386, df=19, p>.025) (see figure 16).

### 3.2.3: Experiment 4 Discussion

**Summary of findings**

The analyses of orientation and disengagement attentional indices with positive and negative stimuli showed that orientation effects were not present in either the high or low introvertive anhedonia groups. The high introvertive anhedonia group also did not display disengagement effects with either positive or negatively valenced stimuli. However, while the low introvertive anhedonia also did not generate a disengagement effect with negative stimuli, they did produce a small significant disengagement effect with positively valenced stimuli.
Comment on findings

The absence of orientation effects in the high and low introvertive anhedonia groups with both positive and negatively valenced stimuli is consistent with hypothesis 1. The absence of these effects is also consistent with both Koster et al. (2004) and Salemink et al. (2007) who found no evidence for the presence of orientation effects using the modified dot probe paradigm.

The absence of disengagement effects with both positively and negatively valenced stimuli in the high introvertive anhedonia group supports hypotheses 2. These results are also consistent with the findings of experiment 2 and suggest that negative schizotypy is associated with blunted processing of both positive and negatively valenced stimuli. Furthermore, a significant disengagement effect in the low introvertive anhedonia with positively valenced stimuli but not negatively valenced stimuli supports hypothesis 3 and is consistent with the positive cue processing preference of the low introvertive anhedonia group seen with emotional Stroop stimuli in experiment 3.

A significant disengagement effect with positive stimuli indicates that the low introvertive anhedonia group’s reaction times to the dot probe, where the dot probe replaced a neutral stimulus when the other stimulus was a positive emotional cue, were slower than reaction times to dots on purely neutral trials. This suggests that when the dot appeared on these positively valenced disengagement trials the low introvertive anhedonia group’s attention was on the emotional stimulus rather than on the neutral stimulus. This would require a disengagement of attention from the current location and a reorientation of attention to the other location in order to identify the dot probe and respond correctly, thus resulting in slower identification of the dot probe.

The results of the current experiment extend those of experiment 3 and suggest that the low introvertive anhedonia group have an emotion cue processing bias to positive stimuli. While experiment 3 examined the competition for processing resource between valenced stimuli and colour naming, the dot probe paradigm used in the current experiment examined how valenced stimuli competed for processing resources with neutral stimuli. The results of the low introvertive anhedonia a group suggest that negative stimuli do not demand more processing resources than neutral stimuli. However, positive stimuli appear to demand a greater amount of processing resources than neutral stimuli.
The disengagement effect of the low introvertive anhedonia group suggests that their attention lingered at the location where the positive valenced stimulus was presented. The identification of the emotional cue as positive might trigger its elaboration in semantic memory thereby demanding an increase in the allocation of cognitive resources. This disengagement effect of the low introvertive anhedonia group could be reflecting an increase in consummatory behaviours. The possibility that positive emotional cues demand increased processing resources in low introvertive anhedonia will be explored further in the next experiment using an affective priming paradigm (e.g. Fazio et al., 1986).

The absence of effects in the high introvertive anhedonia group suggests that valenced stimuli and neutral stimuli were not differentially processed. Their cognitive system does not therefore appear to discriminate between neutral stimuli and positively or negatively valenced stimuli. It is still unclear however whether the high introvertive anhedonia group’s processing of valenced stimuli is actively repressed at an early preattentive stage of stimulus processing or whether valenced stimuli is not processed emotionally. Either explanation would implicate a failure of a preattentive emotional evaluation system with valenced stimuli being either actively tagged as low in valence or by a system that is non responsive to valenced stimuli.

The absence of valenced effects with emotional Stroop stimuli could result from either explanation. The instructions of the experiment demand that word stimuli be ignored while responding to ink colour. The absence of emotional Stroop effects could therefore result from either enhanced active inhibition of emotional cue stimuli or from a preattentive emotional evaluation system that does not activate when presented with valenced stimuli. In contrast, the parameters of the dot probe paradigm does not require that emotional cue stimuli be inhibited or ignored and reaction time latencies to the dot probe measures the consequence of valenced stimuli competing for processing resources with neutral stimuli. Despite this, the absence of valence effects in the dot probe paradigm could still result from early active inhibition of processing valenced stimuli or from an inactive preattentive emotional evaluation system. These issues will be the focus of the following experiment using an affective priming paradigm (e.g. Fazio et al., 1986). It will examine effects of processing a valenced prime on evaluating and categorising a valenced target. The presence of an affective priming congruency effect would suggest that both prime and target are processed emotionally and implicate a preattentive emotional evaluation system that is activated by valenced stimuli.
In sum, the results suggest that the low introvertive anhedonia group have an attentional processing bias to positive stimuli. Such an effect might result from detailed semantic processing of positively valenced cue stimuli. In contrast, the results of the high introvertive anhedonia group suggest that their cognitive system is not differentially sensitive to neutral and positive or negatively valenced stimuli. It is unclear however whether the absence of effect is due to increased active inhibition of processing valenced stimuli or from an inactive preattentive emotional evaluation system.

**Limitations of the Current Study and Future Research**

As in experiment 1, 2 and 3 the high and low introvertive anhedonia groups were not only significantly different on levels of introvertive anhedonia but also on levels of unusual experiences, the O-LIFE’s positive schizotypy dimension. Observed effects cannot therefore be attributed solely to levels of introvertive anhedonia or negative schizotypy. However, multiple regression analyses indicate that orientation and disengagement dot probe indices with positively and negatively valenced stimuli were unrelated to unusual experiences, cognitive disorganisation and impulsive nonconformity schizotypy dimensions and global schizotypy scores.

A further limitation of the current study, which will be addressed in the next experiment, was its inability to provide new information regarding the cognitive and affective processes that might be defective in negative schizotypy. The study provided support for a positive cue processing preference in the low introvertive anhedonia group. However, it did not generate additional information regarding the nature of emotion cue processing in the high introvertive anhedonia group, other than replicating the absence of processing preference biases to positive or negative emotional stimuli observed in experiment 3 with emotional Stroop stimuli. One possibility is that emotional cues are not processed affectively by the high introvertive anhedonia group and therefore not processed differently from neutral stimuli. This will be specifically examined in the following experiment using an affective priming paradigm (e.g. Fazio et al., 1986). The affective priming paradigm involves the presentation of a prime and a target that are either affectively congruent or incongruent. Reaction times are typically faster when prime and target are congruent than incongruent reflecting process of response competition and integration similar to those involved in the Stroop colour word task. The observation of affective congruency effects in the high introvertive anhedonia group would indicate that both the prime and target were processed
affectively. This would imply that the absence of differential emotional cue processing of the high introvertive anhedonia group observed with emotional Stroop stimuli in experiment 3 and in the current experiment with the dot probe paradigm reflects the engagement of mechanisms that repress the processing of valence stimuli.

Conclusion

This experiment examined orientation of attention toward and disengagement of attention from positive and negative valenced emotional cue stimuli in groups scoring high and low on a measure of introvertive anhedonia. There was no evidence for the presence of attentional orientation effects with either positive or negatively valenced stimuli in either the high or low introvertive anhedonia group.

The low introvertive anhedonia group generated an attentional disengagement effect with positively valenced stimuli but not negatively valenced stimuli, which suggests a positive cue emotion processing bias. Such an effect might reflect the elaboration of positively valenced cues in semantic memory. In contrast, the high introvertive anhedonia group did not produce disengagement effects with either positively or negatively valenced emotional cue stimuli. The absence of emotion cue processing effects in the high introvertive anhedonia group may result from either the absence of preattentive emotion cue processing or from mechanisms that actively repress the processing of emotional cues. The next experiment will examine these possibilities in further detail using an affective priming paradigm.

3.3: Interim Discussion 2

The preceding two experiments addressed objective 2 of the thesis by exploring the possibility of an emotion cue processing deficit in introvertive anhedonia. The objective was initially addressed in experiment 3 by examining the performance of a high and low introvertive anhedonia groups on an emotional Stroop task. The emotional Stroop task is thought to measure the degree to which emotional cues capture cognitive resources. This was followed by experiment 4 using a dot probe task, which is thought to reflect the distribution of participant’s attentional resources between emotional and neutral stimuli.
Experiment 3 using the emotional Stroop task found that the low introvertive anhedonia group generated significantly longer reaction times to positive stimuli than negative stimuli. This suggested that for the low introvertive anhedonia group, positively valenced word stimuli captured more cognitive resources than negatively valenced word stimuli. In contrast, the high introvertive anhedonia group responded to both positive and negatively valenced emotional Stroop stimuli to the same degree. They did not produce reaction time differences between positive and negative stimuli. This suggests that they did not preferentially allocate cognitive resources to either positive or negative stimuli.

The absence of a neutral condition in experiment 3 prevented definitive conclusions. The valence effects in experiment 3 using emotional Stroop stimuli established that positive or negative stimuli are preferentially processed. However, they did not establish whether there are processing biases to either positive or negative stimuli. Furthermore, it is also unclear whether emotional Stroop effects result from the effortful avoidance of processing emotional content (De Ruiter and Biosschot, 1994) or from a difficulty in disengaging attentional resources from emotionally salient stimuli (e.g. Waters et al., 2003). Experiment 4 addressed this issue by using a modified dot probe paradigm with emotion cue stimuli and neutral stimuli to provide a measure of attentional orientation toward emotional stimuli and a measure of attentional disengagement from emotional stimuli.

The results of experiment 4 supported the findings of experiment 3. It revealed a clear bias in the low introvertive anhedonia group to the processing of positively valenced emotion cue stimuli. The positive cue processing bias was isolated to the attentional disengagement index which suggested that the low introvertive anhedonia group’s attention lingered at the location where positive cue stimuli was presented. This could be reflecting the allocation of cognitive resources to the internal processing and elaboration of positively valenced emotional cues in semantic memory and reflect processes associated with consummatory pleasure. The results of the low introvertive anhedonia group were also consistent with those of experiment 3. Their processing of emotional stimuli appeared blunted, as they did not preferentially process positively or negatively valenced stimuli over neutral stimuli.

The positive cue processing preference that the low introvertive anhedonia group displayed in experiment 3 and 4 might be expected from those with none or very few introvertive anhedonia traits. Having few anhedonic traits has been associated with high reward responsiveness (e.g. Applegate, et al., 2009) that might reflect a heightened expectation of consuming pleasurable stimuli. This is supported by findings that anhedonia is negatively
associated with self report measure of trait positive affect (Germans and Kring, 2000) but positively associated with trait negative affect (Berenbaum et al. 2006) suggesting that those with few anhedonic traits have enhanced positive affect and diminished negative affect. While the high introvertive anhedonia groups can be characterised as highly anhedonic the low scoring groups might therefore be characterised as highly hedonic. Such groups with atypically few negative schizotypal traits might reflect those in the ‘normal’ sub-clinical population who display pleasure seeking or risk taking behaviours. Such behaviours might be maladaptations to a cognitive system that preferentially processes positive stimuli. Such a cognitive bias might even underpin the development of a personality organisation with few negative schizotypal traits. Such a causal relationship is however currently theoretical but worthy of future investigation.

The absence of a negative emotion cue processing bias in high introvertive anhedonia suggests that negative schizotypy is not characterised by increase in threat processing such as that typically seen in high trait anxiety. The absence of a positive cue processing preference in high introvertive anhedonia could even be the cause of elevated negative effect seen in negative schizotypal groups (e.g. Berenbaum et al., 2006).

In sum, results of experiment 3 and 4 address objective 2 of the thesis by exploring the possibility of an emotion cue processing deficit in introvertive anhedonia. They suggest that ‘negative schizotypy’ is associated with a blunted emotion cue processing system that is characterised by the absence of a processing preference to either positive or negative stimuli. The results further indicate that the low introvertive anhedonia group have a positive emotion cue processing preference that could be reflecting heightened activation of consummatory pleasure systems.

These experiments did not, however, provide any information regarding the cognitive processes that underpin the absence of an emotion cue processing bias in the high introvertive anhedonia group. Emotion cue processing in the high introvertive anhedonia group might be characterised by the absence of automatic preattentive affective processing of emotional cues or from mechanisms that actively repress the processing of emotion cues and their elaboration in semantic memory.

These questions will be addressed in the next experiment that will use an affective priming paradigm. The observation of an affective congruency effect in the high introvertive anhedonia group would indicate that both the prime and target were processed affectively.
This would imply that the absence of emotional biases of the high introvertive anhedonia group, observed in experiment 3 and 4 with the emotional Stroop and dot probe tasks, reflect the involvement of a repressor emotion cue processing mechanisms.

3.4: Experiment 5. Affective Priming

The preceding two experiments using the emotional Stroop and dot probe tasks explored emotion cue processing in low and high introvertive anhedonia groups. The experiments found evidence that the low introvertive anhedonia group processed positive and negative emotion cues differently, which might indicate a positive cue processing preference. However, the high introvertive anhedonia groups did not seem to process positive and negative emotion cues differently in either the emotional Stroop or dot probe tasks. This suggested that they either did not process emotional cues affectively or that they consciously repressed the affective processing of emotional cues. The next experiment will attempt to determine which of these accounts best characterises the apparent blunting of emotion cue processing in high introvertive anhedonia. The experiment will use an affective priming paradigm. The affective processing of primes is thought to be automatic and unavoidable and the observation of an affective priming effect would indicate that both prime and target stimuli were processed affectively.

The Affective Priming Paradigm

The processing of affectively valenced stimuli influences the cognitive and emotional processing of subsequent affective stimuli. This has been demonstrated using the affective priming paradigm, where the affective relationship of prime-target pairs is manipulated (e.g. Bargh, Chaiken, Govender & Pratto, 1992; Fazio, et al., 1986; Hermans, De Houwer & Eelen, 1994). In a typical affective priming paradigm, positively or negatively valenced stimuli (words or pictures) are presented for a short period and are followed by the presentation of a positively or negatively valenced target. Significantly shorter time is typically needed to respond to the target stimuli when the prime and target are affectively congruent (i.e. share the same affective valence) than when the prime and target are affectively incongruent (i.e. have opposite affective valence) or when they have no affective relationship.
Manipulations of the stimulus onset asynchrony (SOA), that is, the time between the onset of prime and the onset of target, indicate that the affective priming effect is time sensitive. The effect is present at an SOA of 300ms but disappears at an SOA of 1000ms (Fazio et al., 1986). Finite manipulations of SOA suggest that the affective priming effect ends at around 300ms and peaks at around 150ms (Hermans, De Houwer & Eelen, 2001). The effect generalises across a number of diverse stimuli such as words (Bargh et al., 1992), nonsense words for which an affective meaning has recently been learned (De Houwer, Hermans & Eelen, 1998) and complex real life pictures (Fazio, Jackson, Dunton & Williams, 1995). The effect is robust and has been demonstrated using tasks that differ in their response demand characteristics including evaluative categorisation (Bargh et al., 1992; Fazio et al., 1986; Hermans et al., 1994), lexical decisions (Wentura, 2000) and word pronunciation (Bargh, Chaiken, Raymond & Hymes, 1996; Hermans et al., 1994).

Explanations of the affective priming effect

Explanations of the affective priming effect, reviewed in detail below, can be classified into automatic spreading activation accounts, expectancy based mechanisms and response competition/facilitation based explanations (Klauer, 1998). A second distinction is whether the mechanism influences the ease of recognising the target stimulus or whether it merely influences the ease of extracting its affective connotation. These distinctions are analogous with an encoding account and a response level account of affective priming. The encoding account of affective priming supposes that primes preactivate memory representations of affectively related targets thus facilitating the encoding of affectively congruent targets (Spruyt, De Houwer, Hermans & Eelen, 2007). In contrast, the response level account supposes that primes trigger a response tendency that facilitates or interferes with target responding. (De Houwer, Hermans & Spruyt, 2001; Spruyt, Hermans, De Houwer, Vandromme & Eelen, 2007). Klauer, (1998) notes, however, that these mechanisms need not be considered mutually exclusive. Rather, different processes are likely to operate simultaneously to produce a complex pattern of results. Fazio (2001) further suggests that affective priming is likely to involve two stages of processing and that the various accounts listed above differ in what process occurs following prime presentation.

A further critical distinction must be made between affective priming in the evaluative categorisation task and affective priming in the pronunciation task. The affective priming
evaluative categorisation task involves the identification and classification of target valence (i.e. is positive or negative, good or bad). In contrast, the affective priming pronunciation task involves the verbal pronunciation of targets. Different task demands change the processes that underlie the affective priming effect (Spruyt, Hermans et al., 2007). De Houwer et al. (2001) note that while both an encoding or response level process can account for affective priming in the evaluation task, affective priming in the pronunciation task can only be due to processes involved in encoding targets (De Houwer, Hermans, Rothermund & Wentura, 2002; Klauer & Musch, 2001; Klinger, Burton & Pitts, 2000; Spruyt et al., 2007; Wentura, 1999). Regardless of the prime-target affective relationships, targets in the pronunciation task are read and pronounced and as such are each linked with a unique response. The presence of an affective congruency effect in the pronunciation task must therefore indicate that the affective processing of primes facilitate the encoding of targets of the same valence rather than triggering a response tendency that facilitates or interferes with target responding.

**Spreading Activation**

In the original affective priming study, Fazio et al. (1986) made reference to the spreading of activation from the prime “along the paths of the memory network, including any evaluative associations” (i.e. positive or negative) (p.231). However, Fazio (2001) suggested that vagueness in the Fazio et al. (1986) study of the specific mechanisms involved has led other researchers to infer an associative network model in which all positive or negative concepts (adjectives, traits or objects) are interconnected in a vast semantic network (Hermans et al., 1994; Klauer, Rossnagel & Musch, 1997; Wentura, 1999). This supposes that activation from a prime spreads to all other concepts with a shared valence. However, as stated by Fazio, 2001, “this was not the view that Fazio et al. (1986) endorsed. Nor is it required by the logic of the experimental paradigm” (p.119). Rather, affective priming involves the spread of activation from the prime (e.g. death) to its associated evaluation (e.g. negative) not to all other concepts with a shared valence (Fazio, 2001).

There is a possibility of a spreading activation account at the stimulus-level, where activation in the node of a prime spreads to nodes linked to it directly or via intermediate nodes in a vast semantic network. However, as argued by Ferguson & Bargh, (2003) this seems unlikely given the tenets of spreading activation models. Ferguson & Bargh, (2003)
highlight that in semantic network models it is assumed that the amount of spreading activation is limited (e.g. Collins & Loftus 1975) and that the magnitude of the priming effect depends on the degree to which the relevant feature of the prime (e.g. living) is common or uncommon to other concepts in memory (e.g. Posner & Snyder 1975). If, for example, a prime has a feature shared by many concepts (e.g. red) then a limited quantity of activation would run out in cue overload or fanning effect (e.g. Anderson and Bower, 1973) and the amount of activation, and therefore facilitation, for any one representation would be minimal. In contrast, if the feature of the prime were fairly unique then a limited quantity of activation would spread to a relatively small number of concepts with the same feature and would therefore facilitate target recognition in congruent conditions. Given that the number of positive and negative concepts in memory is large and assuming that there is a limited amount of activation available, then priming affects due to valence should theoretically be weak (Ferguson & Bargh, 2003). However, the consistent and robust observation of affective priming with a number of stimuli and task demands provides support for the notion, proposed by Fazio, (2001), that prime activation spreads to its associated evaluation rather than all concepts with a shared valence.

Supporting a spread of activation account at the stimulus level, affective priming has been found with words that have strong subjective associations but not with words that have weak subjective associations (Fazio et al., 1986). However, Bargh, et al. (1992), critiqued these findings by highlighting that the prime stimuli selection task, involving participants categorising single words as good or bad as quickly as they could, may have temporarily strengthened word-evaluation associations. These enhanced associations may have carried over to the priming task thereby generating artificial affective priming effects. However, a subsequent replication of Fazio et al.’s (1986) study, that accounted for the temporary strengthening of word-evaluation associations, generated affective priming effects regardless of subjective word-evaluation association strengths (Bargh et al., 1992) suggesting that the affective priming effects are not dependant on subjective associations. Further indication of the affective priming effects generality is its demonstration with randomly selected positive and negative words (Klauer et al., 1997).

While these findings in sum do not confirm or reject the possibility of spreading activation from primes to their associated evaluation they do, however, discount spreading activation at the stimulus level. As stated above, if prime activation spreads through a semantic network activating all other concepts with a shared valence, then affective priming effects should be weak and be dependent on idiosyncratic subjective associations within semantic
memory. However, affective priming effects are robust and not reliant on subjective associations.

**Expectancy and List-Context Effects**

Unlike automatic spreading activation, expectancy-based mechanisms are assumed to be under participants’ strategic and intentional control and to be relatively slow acting (Neely, 1991). It is supposed that participants form an expectancy set upon presentation of a prime that consists of potential targets. For example, participants may come to believe that an evaluatively polarised prime will be followed by an evaluatively consistent target. An explicit, though untested assumption is that an SOA of 300ms is “too brief an interval to permit subjects to develop an active expectancy or response strategy regarding the target adjective that follows; such conscious and flexible expectancies require at least 500ms to develop and to influence responses in priming tasks” (Bargh et al., 1992, pg894 cf. Fazio et al., 1986; Hermans, de Hower and Eelen, 1994). This assumption is based on temporal characteristics of list-context effects, such as the relatedness proportion effect in semantic priming. Typically, as the proportion of semantically related versus unrelated prime-target pairs (i.e. the relatedness proportion) increases then so does the magnitude of semantic priming effects. A relatedness proportion effect is obtained at an SOA of 500ms or longer and decreases or is eliminated at a shorter SOA of 250ms or less (Neely, 1991). The time sensitivity of the effect is thought to reflect the operation of slow acting, controlled processes in the form of expectancy-based strategies.

The manipulation of the proportion of affectively congruent to incongruent prime-target pairs, which Klauer et al. (1997) referred to as consistency proportion (CP), provided a method of testing the relative contribution of automatic and controlled strategic processes in affective priming. As the proportion of affectively congruent to incongruent prime target pairs increases then so does the size of the affective priming effect and presumably indicates the presence of expectancy based response bias. A high proportion of congruent to incongruent prime target pairs leads to the expectation that prime and targets would be affectively congruent resulting in enhanced facilitation to congruent prime-target pairs and increased interference to incongruent prime-target pairs.

Klauer et al. (1997) hypothesised that expectancy based response biases would only develop at longer SOA’s when there was sufficient time for participants to develop an
impression of the proportion of affectively congruent to incongruent prime-target pairs. However, contrary to predictions Klauer et al. (1997) found that with simultaneous (0ms SOA) prime-target presentations CP effects were clearly present with the magnitude of the affective priming effect significantly increasing as the consistency proportion increased.

These CP effects suggest that strategic expectancy based mechanisms may operate in affective priming at a short 200ms SOA and even with simultaneous presentation of prime and target (i.e. 0ms SOA). The presumed 300ms threshold for the operation of active strategies may, therefore, need be adjusted downwards to at least to 200ms and perhaps even to 0ms.

Klauer et al. (1997) proposed an explanation of the CP effect in evaluative affective priming in terms of Logan and Zbrodoff’s (1979) account of CP effects in the classic Stroop colour word task. Logan and Zbrodoff (1979) suggests that that the state of evidence on which participants base their responses in the Stroop colour word task can be expressed as a weighted sum of evidence that is available about the task-relevant stimulus dimension (i.e. colour) and task-irrelevant stimulus dimension (i.e. word). The greater the weight then the stronger the contribution to the participant’s response and weights that represent conscious attentional processing can vary in magnitude and sign (+/-) according to the participants’ current strategy. Changes in sign (+/-) allow responses that are opposite to a habitual meaning by, for example, responding ‘blue’ to a word presented in red. Weights that represent automatic processing are fixed in magnitude and sign. This is assumed by Logan and Zbrodoff (1979) to depend on (a) the degree of practice and (b) the strength and direction of the correlation between the habituated response tendency and the response relevant to the task. For example, in the Stroop colour word task, word reading is a well-practiced habitual process but is task irrelevant. The sign and weight for word reading might therefore be positive but weak. However, dividing attention between the colour and word of Stroop stimuli involves computing and assigning a sign and weight to each stimulus dimension through an act of selective attention. For example, responding to the colour dimension might require a positive sign with a strong weight to be assigned to colour naming and a negative sign with a strong weight to word reading. Logan and Zbrodoff (1979) further propose that participants strategically adjust these weights when they learn that CP is above or below chance level. When the CP is above chance, and there is a greater proportion of congruent to incongruent trials, positive attentional weights are assigned to both task relevant stimulus dimension (i.e. colour) and task irrelevant stimulus dimension (i.e. word) when the CP is above chance. However, when the CP is below
chance and there is a greater proportion of incongruent then congruent trials, a negative weight is assigned to the irrelevant dimension (i.e. word) and a positive weight is assigned to the relevant dimension. As such, classic Stroop effects increase when CP is above chance and decrease when CP is below chance. The eventual response decision is therefore an additive outcome of both automatic and attentional processes. Klauer et al. (1997) suggested that the same logic could be applied to CP effects found at short SOA’s in evaluative affective priming. Participants may strategically divide their attention between primes (the irrelevant stimuli) and targets (the relevant stimuli). CP effects result when participants learn that the CP is above or below chance and therefore assign greater or lesser attentional weights to primes. As such, Klauer et al. (1997) concluded that “the Stroop paradigm is a more appropriate point of reference for affective priming in the evaluative categorization task than the semantic priming paradigm (p.253).

Supporting and extending Klauer et al.’s (1997) findings, Spruyt, Hermans et al., (2007) manipulated the CP (.25, .50 and 75) and the SOA (0, 200 and 1000msec) using both the pronunciation and categorisation tasks. As affective priming effects obtained in the pronunciation task are thought to results from processes that operate at an encoding stage (e.g. De Houwer et al., 2001), then Spruyt, Hermans et al. (2007) hypothesised that expectancy-based mechanisms would not be operating and that the magnitude of affective priming effects at a short SOA would be unaffected by variation in CP. In contrast, as affective priming effects obtained with the evaluative categorisation task are thought to be influenced by processes that operate at a response stage, then Spruyt, Hermans et al. (2007) expected the involvement of expectancy based mechanisms and therefore clear CP effects to be present at short SOA’s. The results supported both of these hypotheses therefore providing additional support for distinct processes underpinning affective priming effects with the pronunciation and categorisation tasks. Spruyt, Hermans et al. (2007) further reported that affective priming effects were more pronounced in the 200 msec than in the 0 msec condition in the categorisation task but more pronounced in the 0msec than in the 200 msec condition in the pronunciation task. Spruyt, Hermans et al. (2007) suggested that such results again reflect the involvement of distinct processes with evaluative categorisation and pronunciation tasks. As affective priming with the categorisation task is considered to be strongly influenced by processes that operate at a response selection stage then, as observed in the results, the magnitude of affective priming effect would be expected to increase from a 0msec to 200 msec SOA condition. However, as affective priming with the pronunciation task is considered to be strongly influenced by processes that operate at an encoding stage then, as again observed in the results, such an increase in
the magnitude of affective priming would not be expected from a 0 to a 200 msec SOA. A
decrease in affective priming might even be expected over time due to activation of the
prime decaying thereby reducing its influence on the encoding of targets.

In sum, consistency proportion effects indicate that expectancy based mechanisms operate
in the affective priming effect with evaluative categorisation but not with the pronunciation
of targets thus supporting the involvement of distinct processes at a response and encoding
stage in each task respectively. Expectancy based mechanisms appear to be fast acting
even operating with simultaneous prime-target presentations that involve the changing of
attentional weights assigned to primes akin to the selective attention processes involved in
the classic Stroop colour word task (Klauer et al., 1997; Logan and Zbrodoff (1979)

**Response competition/facilitation (Explanations Adapted from The Stroop Paradigm)**

As introduced above, affective priming in the categorisation task has much in common
with Stroop-like tasks of selective attention (Hermans, De Houwer and Eelen, 1996;
Klauer, 1998; Klauer et al., 1997; Klinger et al., 2000; Wentura, 1999). These paradigms
focus on mechanisms of response competition or facilitation and specifically the processes
of choosing a to-be selected target against a to-be-ignored distracter (MacLeod, 1991) or
the interference of the irrelevant distracters with the processing of a relevant target.

The evaluative affective priming paradigm conforms to Algom, et al.’s (2004) defined
features of classic Stroop stimuli, that is, the presence or absence of congruence, the
requirement that at least one dimension of the stimulus be semantic in nature and the
qualification that the semantic association may come from incidental or environmental
correlations as well as from the ‘natural meaning’ that words acquire. In the evaluative
affective priming paradigm, there exists a logical relationship of compatibility and
incompatibility, that is, the presence or absence of congruence. Congruent stimuli are
those in which values from two dimensions are associated with the same task-appropriate
response whereas incongruent stimuli are ones in which one dimension is associated with
one task appropriate response and the other with a different task appropriate response. In
evaluative affective priming the prime-target relationship (affectively congruent vs.
incongruent) is confounded with the prime-response relationship (prime valence matching
the response vs. non-matching). Whenever the prime is congruent to the target (e.g. when
death is the prime for the target repulsive), its valence matches the required response (negative). Whenever the prime is incongruent to the target (e.g. gift/repulsive), its valence mismatches the required response. Primes in the evaluative affective priming task therefore have a high degree of task relevance because they can be classified as positive or negative as easily as targets. The affective evaluative priming task, as in any prototypical Stroop-like paradigm, therefore has a high degree of task relevance of the distracter and can be explained by processes of pathway interference and/or pathway facilitation. Presentation of a prime might trigger a response process due to its affective value. Therefore, when prime and target are affectively congruent, facilitation of the correct response may occur. Conversely, when prime and target are affectively incongruent, interference of competing pathways might slow down responses. In comparison, naming the colour of a stimulus in the Stroop task corresponds to evaluating the target and the congruent or incongruent colour word corresponds to the prime/distracter in the affective evaluation task. Klauer et al., (1997) drew similar comparisons between evaluative affective priming and the Eriksen flanker task (Eriksen and Eriksen, 1974).

The flanker task presents a row of letters and the task demands that the centre letter is concentrated upon while simultaneously ignoring flanking letters presented on either side. One response key corresponds to one set of targets (e.g. A and B) and another key to an alternative set (e.g. C and D). Typically, responses are facilitated when the flanker belongs to the same response set as the centre letters (e.g. BAB) and slow when flankers are from the alternative set (e.g. CAC) thus suggesting that flankers cannot be completely ignored. Similarly, in the evaluative affective priming paradigm also has two response sets (i.e. set of positive and set of negative words). A different response is required to words from differing sets (e.g. left button = negative word, or right button =positive word). In this analogy, the irrelevant flankers in the priming task are the prime words. These interfere with correct target responses when the flanker and target come from different response sets (i.e. when the prime and target are affectively incongruent).

Cohen et al.’s (1990) connectionist model of the mechanisms involved in the performance of the Stroop task can also be drawn upon as a model of the mechanisms involved in the evaluative affective priming paradigm (Klinger et al., 2000). Cohen, et al’s (1990) parallel distributed processes model proposes that processing occurs via pathways of different strengths. Presenting a stimulus activates input units corresponding to, in the case of the Stroop task, the word and colour. Changing activity in the task demand unit/module determines the degree to which word reading or colour naming dominates subsequent
Colour naming requires greater activation of the task demand module for competition with a stronger process (i.e. word reading). The task demand unit/module therefore provides the internal representation of context (i.e. the instruction to respond to colour not word) for disambiguating stimuli. Interference is produced in the model when two simultaneously active pathways produce conflicting activation at their intersections (i.e. red colour / green word). Facilitation is seen when two pathways produce coinciding activation (i.e. red word / red colour). When one of the output units crosses its threshold, a response is produced. In the case of evaluative affective priming the prime and target activate pathways of equal strength that correspond to the affective value of the stimulus (i.e. positive or negative). When the prime-target relationship is incongruent their pathways conflict thus reducing activation and therefore taking longer to reach threshold. In contrast when the prime-target relationship is congruent their pathways produce coinciding activation. As pathways in the affective priming paradigm are of equal strength then responding to incongruent targets does not involve the overriding of prepotent responses, as in the Stroop colour word task, but more likely the resistance to distracter interference (Nigg 2000). Kane et al. (2001) suggests that resistance to distracter interference requires maintaining the task goal in a state of high activation in the face of a more dominant but inappropriate responses or to distracting stimuli in the environment. As in the Stroop colour word task, therefore, resisting the distracting interference of primes in the evaluative affective priming paradigm would involve maintaining task instruction in a state of high activation whilst processing and responding to incongruent targets.

Cohen et al.’s (1990) model can be further applied to the findings of previous affective priming studies. The model can explain why affective congruency effects are only typically observed at short, 0 - 150ms, SOA’s (e.g. Hermans et al., 2001; Klauer et al 1997). At short SOA’s, the prime and target in evaluative affective priming paradigm are processed holistically as one stimulus. In accord with Cohen, et al.’s (1990) model, at 0ms SOA the valence of both the prime and target activate pathways simultaneously and are processed in parallel. At a brief SOA (i.e. shorter than 300ms) the prime pathway is still active when the target pathway is activated and is still, therefore, able to strengthen or weaken the target processing pathway. However, at longer SOA (i.e. longer than 300ms) the valence of prime and target are processed as distinct events. Activation generated by the prime at these longer SOA’s may have dissipated by the time the target pathway is activated. Cohen, et al.’s (1990) model can further help explain why affective priming effects are less consistent when the task is word pronunciation, as some report the presence of the effect (e.g. De Houwer et al., 1998; Klauer & Musch, 2001; Spruyt, Hermans et al.,
2007) while other do not (e.g. Bargh et al., 1996; Hermans et al., 1994), or when the task
demands the categorisation of targets on the basis of non-affective semantic features (e.g. 
De Houwer et al, 2002; Klinger et al 2000). The lack of priming in these cases may be due
to the absence of conflict at response selection. Pronouncing the target or categorising it
on the basis of non affective features does not create a conflict with the valence of primes
at response selection (see De Houwer et al., 2001; Spruyt, De Houwer, et al., 2007).

Further evidence supporting the validity of comparing the evaluative affective priming and
the Stroop paradigm comes from the similarities in their pattern of findings. As in the
evaluative priming effect, Stroop effects are typically found for short SOA’s but not for
long SOA’s (MacLeod, 1991). Both the evaluative affective priming task (Klinger et al.,
1997; Spruyt, Hermans et al., 2007) and Stroop colour word task (MacLeod, 1991) display
list-context effects at short SOA and even with simultaneous presentation of the task
irrelevant and task relevant dimensions. Furthermore, facilitation and inhibition, relative to
baseline, are observed in both the Stroop colour word task (MacLeod, 1991) and the
evaluative affective priming paradigm (e.g. Fazio et al., 1986).

In an explicit test of the Stroop/affective priming paradigm analogy, Wentura (1999)
argued that if the affective priming effect is due to a conflict between responses that are
activated by the prime and target, assuming that the prime serves as a distracter for
processing the target, then a negative priming effect would result. Essentially, the
processing of affectively incongruent prime and target on trial n-1 (i.e. the prime trial)
would result in the slowing of responses on trial n (i.e. the probe trial) if the target stimuli
of the probe-trial were affectively congruent to the prime stimuli of the prime-trial (see
table 22). This hypothesis was confirmed and a negative priming effect from trial n-1 to
trial n was observed. The observation of such an effect provides support for Stroop-like
interference as one mechanism involved in the affective priming effects. Wentura (1999)
suggested that the results favour a view that affective priming effects in the evaluation task
are due to processes involved in response pathway interference that are resolved by an
inhibition of the tendency to respond to the prime. The observation of negative priming
specifically implies that the active inhibition of the response pathway corresponding to the
prime on trial n-1 (e.g. positive) resulted in reduced activation of the same response
pathway when it corresponded to the target on trial n.
### Table 22
Example of negative priming in evaluative affective priming (Wentura, 1999)

<table>
<thead>
<tr>
<th>Trial type</th>
<th>Prime</th>
<th>Target</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prime-trial (n-1)</td>
<td>Positive</td>
<td>Negative</td>
<td>Negative priming (i.e. Slowed RT response to target)</td>
</tr>
<tr>
<td>Probe trial (n)</td>
<td>Negative</td>
<td>Positive</td>
<td></td>
</tr>
</tbody>
</table>

**Explanations based on SOP**

Wagner’s (1981) sometimes opponent process (SOP) model is a real time process model of classical conditioning. It proposes that stimuli are represented in associative memory by nodes that consist of a number of elements. These elements represent a number of properties of the stimuli such perceptual and semantic. These elements can exist in three states: a state of inactivation, a primary state of activation, referred to as the A1 state and a secondary state of activation referred to as the A2 state. Inactive nodes are considered to be in long term store whereas the primary state of activation (A1) is analogous to the focus of attention and the secondary state of activation (A2) is analogous to working memory.

When a cue or outcome is unexpectedly presented a proportion of the elements of a corresponding node are thought to move from a state of inactivation to the primary A1 state of activation. These elements rapidly decay from the A1 into the A2 state of activation and eventually return to a state of inactivation. It is assumed that nodes can only be in one state at a given time and that they cannot move directly from the A2 to the A1 state. Wagner (1981) conjectured that when nodes of two stimuli (e.g. X and Y) are concurrently in the A1 state then an excitatory association will develop between the nodes of the two stimuli. The subsequent activation of a node by an associative connection bypasses the A1 state and leads directly to A2. The subsequent presentation of stimulus Y will therefore generate the A2 state of activation in a proportion of X’s elements.

The SOP model can account for affective priming effects and provides an interpretation of affective priming in relation to the participants conditioning history. If stimuli of the same valence are associated in memory then the presentation of a prime will active the elements of other similarly valenced stimuli into the A2 state of activation. These stimuli will therefore be primed from a state of inactivation in long-term memory to a secondary state.
of activation in working memory. When a target is presented its representation is already primed into working memory and facilitates the behavioural valence categorisation response. In contrast, if a target is of a differing valence then elements of its representation will not be primed in working memory. The majority of the representations elements would be in the A1 state that is analogous to the focus of attention. This would cause behavioural interference as the target elements decay from the A1 state to the secondary A2 state of activation that enables its valence categorisation.

**Automatic vs. controlled processes in affective priming**

Affective priming effects typically occur at simultaneous presentation of prime and target, peaking at around 150ms and ending at around at around 300ms (e.g. Hermans et al., 2001). However, the masking of primes so they are consciously undetectable still results in affective priming effects. Greenwald, Klinger and Liu (1989) report three experiments in which primes were masked dichoptically by the presentation of a random letter-fragment pattern to the dominant eye either rapidly following the prime (experiment 1) or simultaneously with the prime (experiment 2 and 3). The effectiveness of the masking procedure was demonstrated by the subject’s inability to discriminate the left versus right position of a test series of words viewed under the same masking conditions as the prime stimuli in the priming task. Significant masked affective priming effects were obtained in all three experiments. This strongly suggests at the involvement of an automatic component in affective priming and provides support for the affective primacy hypothesis (Zajonc, 1980; 1984). The hypothesis states that positive and negative affective reactions can be evoked with minimal stimulus input and virtually no cognitive processing. In a direct test of the affective primacy hypothesis Murphy and Zajonc (1993) presented faces expressing emotion for 4ms followed by immediate presentation of target stimuli consisting of Chinese ideographs (e.g. ☰), which also served as a backward mask. In this suboptimal condition, presentation of these affective primes influenced subjects’ liking of (experiment 1) and goodbad judgements of (experiment 2) the target ideographs. However, presentation of ‘cognitive’ primes, including large and small circles, symmetrical and asymmetric shapes and male and female faces, were ineffectual in the judgments of size (experiment 3), symmetry (experiment 4), and gender (experiment 5) of ideographs. Furthermore, at optimal 1000ms prime exposure this pattern of results was reversed with cognitive primes (size, symmetry and gender) but not affective primes effecting judgements.
These results also provide support for a continuum model of consciousness (Ohman, 1988) where affective information is processed early before more complex perceptual features of stimuli. With suboptimal 4ms exposure that is further degraded with backward masking, affective processing of primes might take place and give rise to global cognitive and physiological affective reactions. Murphy and Zajonc (1993) make reference to free-flooding anxiety, a state in which the origin and target of the affective cue are not accessible to an individual’s awareness. However, at 1000ms prime exposure, additional information may be available from a more extensive cognitive appraisal. Inconsistency between early affective information and subsequent cognitive information may dilute the affective reaction thus cancelling the priming effect. Murphy and Zajonc (1993) concluded that when affect is elicited outside conscious awareness, it is diffuse and non specific, and its origin and address are not accessible. Such gross and non specific affective reaction could therefore be diffused or displaced onto unrelated stimuli.

The observation that affective priming occurs with both consciously detectable and undetectable primes is consistent with a conditional approach to automatic processes (Barh, 1989, 1992, 1994). Automatic processes can be characterised by a set of defining features - intentional vs. unintentional, efficient vs. attention demanding, dependent on awareness vs. not dependent on awareness and controllable vs. uncontrollable - that do not have to co-occur in an all or none fashion. A process might, for example, be unintended, but controllable and requiring some attentional resources. Several types of automatic processes are therefore likely in combinations of different features. Automaticity cannot, therefore, be viewed as a unitary concept that is fast, parallel, involuntary, effortless, unintentional and occurring outside of awareness that cannot be inhibited. Such a conditional approach to automaticity can be applied to the affective priming effect.

Findings that priming occurs only with short SOA’s (e.g. Hermans et al., 2001) suggest that primes are processed quickly and in parallel with the target. Furthermore, finding that primes affect the judgments of neutral objects (Greenwald et al., 1989) suggests that the processing of primes and its affect on subsequent stimulus is uncontrollable. However, CP effects at short SOA (Klauer et al., 1997; Spruyt, Hermans et al., 2007) suggest that some controlled processing of primes occur. Furthermore, the observation that masked and unmasked primes both produce priming suggests that awareness/unawareness may not be a dependant feature of the affective priming effect. Posner and Peterson (1990) noted that the attentional system can be subdivided into three different but interrelated subsystems: (a) orienting to sensory events, (b) detecting signals for conscious processing and (c) maintaining a vigilant or alert stage. These subsystems correspond to preattentive,
attentive and postattentive possesses respectively. In accord with a conditional approach to automaticity prime processing might therefore involve both preattentive and attentive processes.

**Comparisons Between Affective Priming and the Emotional Stroop Task**

As highlighted above, similar cognitive mechanisms are thought to be involved in the evaluative affective priming paradigm and the classic Stroop colour word task. Furthermore, since the evaluative affective priming paradigm has an affective element, it places demands on both cognitive and emotional processes and cortical structures. As such, the affective priming evaluative categorisation task can be considered as more of a valid emotional Stroop task than the emotional Stroop task itself. In a discussion of the conceptual divide that separate the Stroop colour word and emotional Stroop tasks, Chajuta et al. (2005) referred to McKenna and Sharma (2004) who state “that the emotional Stroop effect is not strictly speaking a Stroop effect…Although the term emotional intrusion effect might be preferred, the term emotional Stroop is now well established” (p. 382).

The emotional Stroop effect is a list based phenomena, as item specific effects are not typically found (Algom, et al., 2004). A slow component, or carry over effect occurring between items and disrupting reaction times on subsequent items to emotional stimuli (Mckenna and Sharma, 2004; Waters et al., 2003) is thought to be responsible for the absence of an item based effect. Such a carry over effect, however, lies at the core of the evaluative affective priming paradigm. At short SOA’s, activation of primes carry over and is either integrated with or conflicts with target responding.

If it is assumed that the affective content of primes in affective priming is processed, to a degree, automatically, then its influence may be unavoidable. This feature has greater similarity with the classic Stroop colour word task, where interference comes from a response conflict resulting from the words semantic content. That is, interference is a result of a prepotent response to read the word, which contains conflicting or supporting semantic information to the ink colour. It is similarly presumed in the emotional Stroop task that the semantic content of an emotional word causes interference in naming ink colour. However, prepotency to read words in the emotional Stroop task does not create a response conflict and both word and colour can be processed in parallel. In contrast, the
semantic content (or affective value) of prime words in the affective priming task is integrated with or interferes with the semantic content (or affective value) of target words.

Furthermore, emotional Stroop effects are thought to result from a general purpose threat driven mechanism (e.g. Chen and Bargh, 1999; Pratto and John, 1991; Wentura et al., 2000), which slows response latencies due to a reorienting of cognitive resources to the detection of further threat (e.g. Algom et al, 2004; Bar-Haim et al., 2007). However, the processing of emotional Stroop stimuli is thought to involve later stages of a continuum of consciousness that is under conscious control (e.g. Bar-Haim et al., 2007; Phaf and Kan, 2007). As such, conscious strategies are employed to inhibit the processing of emotional words and respond to the words print colour. It therefore makes data generated from the paradigm difficult to interpret. For example, do longer latencies to threat words reflect the heightened involvement of an automatic general purpose threat driven mechanism or the effortful involvement of a repressor strategy. Conversely, do shorter response latencies reflect the absence of an automatic general purpose threat driven mechanism or a conscious strategy to ignore the processing of the words threat content? If it is presumed that at short SOA’s the influence of primes is consciously unavoidable then it can be argued that the affective priming task may require prepotent response inhibition of the prime in the incongruent condition rather than the resistance to distracter interference. In accordance with the affective primacy hypothesis (Zajonc, 1980; 1984) interference in the task would come from the primes affective valence. The affective priming paradigm may therefore provide a more accurate measure of attentional bias to emotional words by measuring the strength of prime processing pathways rather than conscious strategies involved in effortful avoidance. For example, Hermans, Spruyt and Eelen (2003), demonstrated that originally neutral stimuli, that acquired a negative affective valence through a differential aversive conditioning procedure, produced priming effects when used as primes in an evaluative categorisation task. Similarly, De Houwer et al. (1998) demonstrated that nonwords, previously paired with valenced words and memorised, when used as primes also produced an affective priming effect in an evaluative categorisation task.

**Affective Priming and Schizotypy**

A search of the literature identified two studies that have examined associations between performance on the affective priming paradigm and schizotypal trait dimensions. Kerns
and Berenbaum (2000) examined semantic and affective processing in positive and negative schizotypy as measured by the perceptual aberration and magical ideation scales (positive schizotypy) and the social anhedonia scale (negative schizotypy). They used a pronunciation task with continuously presented mixed trials of semantically related and unrelated but affectively neutral items and affectively related, congruent and incongruent, positive and negative word pairs. The positive schizotypy group displayed greater semantic priming than the control and negative schizotypy group. The positive schizotypy group was sensitive to the valence of primes. Their responses to affectively congruent and incongruent word pairs with positive primes were quicker than baseline while their responses to congruent and incongruent word pairs with negative primes were slower than baseline. In contrast, the negative schizotypy group were sensitive to the valence of targets as their responses to congruent and incongruent word pairs with positive targets were quicker than baseline while their responses to congruent and incongruent word pairs with a negative target were slower than baseline. Furthermore, the effect of target valence in negative schizotypy was associated with semantic priming. Kerns and Berenbaum (2000) concluded that the increased semantic priming observed in positive schizotypy was suggestive of increased automatic spread of activation. Furthermore, the affect of prime valence observed in the positive schizotypy group suggests that they are overly influenced by the affective valence of preceding stimuli in processing current information. In contrast, the negative schizotypy group’s sensitivity to target valence and its association to semantic priming was interpreted as the negative schizotypal group’s tendency to process affective information in a semantically detailed but affectively shallow manner. The affective priming results in negative schizotypy could therefore be reflecting either a disruption in a preattentive affective evaluation system, or, an affective processing bias at later conscious attentive stages of processing.

The only study to use the evaluative categorisation affective priming task with a schizotypy sample was reported by Kerns (2005). It focused solely on the positive schizotypal dimension as measured by magical ideation and perceptual aberration scales. Compared to a ‘normal’ control group the positive schizotypy group displayed no reaction time priming effects at a short 150ms SOA; that is, no reaction time difference between affectively congruent and incongruent prime-target word pairs. At the short SOA affective priming effects were apparent in the error data for the positive schizotypy group but not control group. Kerns (2005) further found with the collection of a battery of self report measures that a significantly large proportion of the positive schizotypy group were classified as *emotionally overwhelmed* which Kerns (2005) suggested might have resulted
from the group’s tendency to display increased attention to emotions and reduced emotional clarity. Kerns (2005) proposed that the results indicate that multiple emotion processing deficits are present in positive schizotypy and that these may be additional to disturbances of a cognitive and perceptual origin.

The absence of an affective priming congruency effect in the positive schizotypy group may reflect the presence of a repressor strategy. A tendency to increase attention to emotions but having reduced emotional clarity may have resulted in the positive schizotypy group becoming emotionally overwhelmed and attempt to end trials quickly resulting in no reaction time priming but a priming error effect. However, Kerns (2005) found no evidence of speed accuracy tradeoffs suggesting that separate processes may account for the reaction time and error data.

Despite evidence indicating that priming in the evaluative categorisation task results from mechanisms of response competition/facilitation whilst priming in the pronunciation task results from encoding mechanisms, it is likely that neither process is mutually exclusive to each particular task (Fazio, 2001). Rather, the degree of influence that each mechanism has on affective priming is likely to vary on a continuum from target categorisation to target pronunciation. Kerns’ (2005) reaction time and error data for the positive schizotypy group may therefore reflect the interaction of encoding mechanisms and response competition respectively. As argued above, the automatic processing of primes (Greenwald et al., 1989) is somewhat conditional (Bargh, 1989, 1992, 1994) and CP effects at short SOA (Klauer et al., 1997; Spruyt, Hermans et al., 2007) further suggest that some controlled processing of primes occurs. The absence of reaction time priming in the positive schizotypy group could, therefore, be reflecting some repressor strategy resulting from being emotionally overwhelmed. Such a repressor strategy might still allow the valence of primes to be detected (i.e. good or bad) but prevent elaboration of primes in semantic memory. Therefore, the absence of affective priming in the reaction time data suggests that primes were not encoded in sufficient detail to interfere with or facilitate detailed encoding of targets. However, error-priming effects for the positive schizotypy group suggest that error/mismatch detection mechanisms were operating successfully. In analogues with the Stroop task, the evaluative categorisation affective priming paradigm places greater demands on executive functions during incongruent trials. An executive functioning deficit may therefore account for the positive schizotypy group’s priming effect in the error data.
Predictions and hypotheses

The affective priming paradigm may involve both the encoding of primes and the subsequent spread of activation to related concepts in memory, mechanisms of response competition and expectancy mechanisms. The degree to which each mechanism is involved appears to depend on the demands of the task and the relative proportions of affectively related and unrelated prime-target pairs. However, all mechanisms appear to involve the unavoidable and automatic affective processing of primes that either enhance or interfere with the affective processing of targets. The involvement of this basic process in affective priming will be used to examine whether the affective processing of stimuli is reduced or absent in negative schizotypy.

The current experiment will examine affective priming congruency effects in high and low introvertive anhedonia groups. Congruency effects are the difference that processing an affective prime has on the valence categorisation response to affectively congruent and incongruent targets. Typically, responses to affectively congruent prime-target pairs are facilitated. These congruency effects were calculated for negative targets as the response difference between incongruent positive→negative (+-) prime-target pairs and congruent negative→negative (--) prime-target pairs (i.e. + vs. --). For positive targets, these congruency effects were calculated as the response difference between incongruent negative→positive (-+) prime-target pairs and congruent positive→positive (++) prime-target pairs (i.e. -+ vs. ++).

The experiment will specifically test whether the high introvertive anhedonia group’s absence of valence effects with emotional Stroop stimuli (experiment 3) and with the dot probe paradigm (experiment 4) were due to failures of preattentive emotional cue evaluation systems that process emotional cues affectively. If participants with many introvertive anhedonic traits do not processes emotional cues affectively then they would not generate an affective priming congruency effect (Hypothesis 1). If primes are not processed affectively then they would not interfere with the processing of affectively incongruent targets or facilitate the processing of affectively congruent targets. However, if the those with many introvertive anhedonic traits do process emotional cues affectively then they would generate an affective priming congruency affect (Hypothesis 2). If primes were processed affectively then they would interfere with the processing of affectively incongruent targets and facilitate the processing of affectively congruent targets. Furthermore, if a high introvertive anhedonia group does generate affective
priming effects then it might be expected that their blunted processing of positive and negative stimuli seen in experiment 3 and 4 would produce comparable priming effects for prime-target pairs with positive and negative targets (Hypothesis 3).

Valence effects with emotional Stroop stimuli (experiment 3) and with the dot probe paradigm (experiment 4) indicate that the low introvertive anhedonia group are sensitive to the valance of emotional cue stimuli. It would therefore be expected that a low introvertive anhedonia group would generate an affective priming congruency effect (Hypothesis 4). The affective processing of primes should interfere with the processing of affectively incongruent targets and facilitate the processing of affectively congruent targets. Furthermore, results of experiment 3 and 4 suggest that the low introvertive anhedonia group preferentially process positively valenced emotion cue stimuli. This should therefore produce group specific affective priming effects for prime-target pairs with positive targets and prime-target pairs with negative targets. A preference of the low introvertive anhedonia group for the processing of positively valenced stimuli should generate larger affective priming effects for prime-target pairs with negative targets than for prime-target pairs with positive targets (Hypothesis 5). The preferential processing of positive primes should result in increased interference whilst responding to incongruent negative targets.

3.4.1: Experiment 5. Method

Introduction

The current experiment examined affective priming congruency effects in high and low introvertive anhedonia groups. If congruency effects were observed then it would suggest that both the prime and target were processed affectively. Furthermore, if the degree of affective priming were different for prime-target pairs with differing valences, then this would provide additional support for differential processing of valenced emotional cue stimuli in low introvertive anhedonia group. However, it is likely that differences in the automatic spread of activation are an additional endophenotype of schizotypy (e.g. Evans, 1997). For example, Kerns and Berenbaum (2000) observed an increase in semantic priming in positive schizotypy, which is indicative of an enhancement in the automatic spread of activation in semantic memory. Given that the occurrence of schizotypal traits from the positive, negative and disorganised clusters are not discrete and are to a degree
co-morbid then controlling for the confounding influence of difference in the spread of activation in affective priming seems prudent. Affective priming in the current experiment was therefore conducted with situationally (physical and social) unrelated prime-target pairs. The affective relationship of prime-target pairs was manipulated while the situational relationship was always incongruent. A congruent condition, for example, presented a positive prime from a social situational category and a positive target from a physical situational category. An incongruent condition, for example, presented a positive prime from a social situational category and a negative target from a physical situational category (see table 23).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prime</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Situationally Unrelated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affectively Incongruent</td>
<td>Negative Physical</td>
<td>Positive Social</td>
</tr>
<tr>
<td></td>
<td>Negative Social</td>
<td>Positive Physical</td>
</tr>
<tr>
<td></td>
<td>Positive Physical</td>
<td>Negative Social</td>
</tr>
<tr>
<td></td>
<td>Positive Social</td>
<td>Negative Physical</td>
</tr>
<tr>
<td>Affectively Congruent</td>
<td>Positive Physical</td>
<td>Positive Social</td>
</tr>
<tr>
<td></td>
<td>Positive Social</td>
<td>Positive Physical</td>
</tr>
<tr>
<td></td>
<td>Negative Physical</td>
<td>Negative Social</td>
</tr>
<tr>
<td></td>
<td>Negative Social</td>
<td>Negative Physical</td>
</tr>
<tr>
<td><strong>Situationally Related</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affectively Incongruent</td>
<td>Negative Social</td>
<td>Positive Social</td>
</tr>
<tr>
<td></td>
<td>Negative Physical</td>
<td>Positive Physical</td>
</tr>
<tr>
<td></td>
<td>Positive Social</td>
<td>Negative Social</td>
</tr>
<tr>
<td></td>
<td>Positive Physical</td>
<td>Negative Physical</td>
</tr>
<tr>
<td>Affectively Congruent</td>
<td>Positive Social</td>
<td>Positive Social</td>
</tr>
<tr>
<td></td>
<td>Positive Physical</td>
<td>Positive Physical</td>
</tr>
<tr>
<td></td>
<td>Negative Social</td>
<td>Negative Social</td>
</tr>
</tbody>
</table>

**Participants**

Forty-seven participants were recruited into the study with 72.3% being female. The sample had a mean age of 25.1 years with a standard deviation of 10.1. The recruitment of low and high introvertive anhedonia groups was identical to that in the previous 4 experiments. The definition of high and low introvertive anhedonia was again based on upper and lower quartile age and gender norms for the normed introvertive anhedonia distribution (Mason and Claridge, 2006, see table 5). Exclusion criteria were also identical to those in experiment 4 and included non-corrected vision less than 20/20 and being under
the influence of substances known to distort mood, perception and or attention. The size and basic demographics of the high and low introvertive anhedonia groups (i.e. gender and age) were not known until the end of data collection and are therefore reported in the results section.

Materials

The evaluative affective priming paradigm was programmed and presented using DMDX, a windows-based program with millisecond timing accuracy (Forster and Forster 2003). Four situational word categories were used; social negative, physical negative, social positive and physical positive. Three words per category were sourced from the affective norms for English words (ANEW) list (Bradley & Lang 1999), normed for social/physical category membership (see appendix 3) and balanced across categories on valence (i.e. positive/negative) arousal (high/low) and length (see appendix 4). Each word was presented only once as a prime and only once as a target paired with each of the other words as a prime and target in all possible combinations. For example, the word ‘kiss’ was presented only once as a prime paired with the word ‘friend’ as a target. The same word ‘kiss’ was also only presented once as a target with the word ‘friend’ as a prime. This yielded 144 prime-target pair trials with 9 exemplars grouped into 16 conditions. Eight of these conditions consisted of situational unrelated prime-target pairs. Half of these eight conditions had affectively congruent prime-target pairs and half had affectively incongruent prime-target pairs (see table 23). An additional eight prime-target pair items were created as practice trials. These consisted of eight words that were situationally unrelated to the critical stimuli (i.e. neither social nor physical). Four of these words were used as primes and were affectively neutral. Targets consisted of the other four words, two of which had positive valence and two had negative valence (see appendix 4). All texts were presented in Times New Roman, size 26 font producing a screen letter height in DMDX of approximately 1.5cm.

Procedure

Verbal consent was gained from participants before the start of experimental testing and the experimenter ensured that none met any of the exclusion criteria. All participants completed critical trials alone in an experimental testing booth. They were asked to sit at a
comfortable distance, approximately 1 meter, from the computer screen. An instruction page was then displayed which introduced and presented the requirements of the task. These instructions were also relayed to the participants verbally.

Participants initiated the experiment by pushing the spacebar. Each trial began with a fixation (****) presented in blue print for 500ms at the centre of a black screen. This was immediately replaced (i.e. one refresh rate of the monitor) by the prime, which was presented for 150ms again in blue print. The target immediately replaced the prime and was presented in yellow print until a response was made or until 2000ms had elapsed at which point a ‘no response’ was recorded. The target was replaced by a blank screen, which remained for 2000ms. Continuous presentation of trials therefore provided a consistent inter trial interval of 2000ms and a maximum trial length of 4650ms.

Participants were asked to read both words but respond only to the second word presented in yellow print. They were asked to indicating whether the word was good/positive or bad/negative by pushing either the right or left control key on the keyboard. Response keys were counterbalanced across participants. An equal emphasis was placed on response speed and accuracy.

Ten blocks of stimuli were presented. The first block contained practice items. Each of the remaining 9 blocks contained 16 trials; one exemplar from each condition. A short break followed each block, which participants ended and continued with the task by pushing the spacebar. Blocks were presented in a randomised order and the trials within them were also randomly presented.

The experimenter observed and supervised completion of the practice block to ensure that participants understood the demands of the task. Following testing participants were given a full de-brief.

Method of Analyses

Since the focus of the experiment was on affective processes the analyses presented below only examined affective priming with the eight conditions of situational unrelated prime-target pairs. This was designed to control for possible group differences in the spread of activation from primes to related concepts in semantic memory. The distinction between social and physical pleasure/threat was redundant (see experiment 3) and data for positive
and negative targets in the current experiment were collapsed across situational categories 
(social/physical).

The first set of analyses intended to account for the possible confounding influence of 
other schizotypal trait dimensions on affective priming congruency effects with prime-
target pairs with positive and negative targets. Both reaction times and errors were 
alysed, as they are equally valid dependent measures of priming effects

Two multiple regression analyses were first conducted one with a reaction time measure of 
affective priming for prime-target pairs with positive targets (RT+- minus RT) as the 
dependant variable and the other with a reaction time measure of affective priming for 
prime-target pairs with negative targets (RT+- minus RT--) as the dependant variable. 
Both analyses included the schizotypy trait dimensions that were not of direct relevance to 
the current investigation as predictor variables. All data were screened for outliers, which 
if present were removed from the analyses. Furthermore, normality of the data was 
assessed and if significant skew were present then the variable was transformed until 
normality was achieved.

The error measure of affective priming for prime-target pairs with positive targets 
(proportion of errors to + to - minus proportion of errors to + to +) and prime-target pairs with 
negative targets (proportion of errors to + to - minus proportion of errors to - to -) did not meet 
the testing assumptions for regression analyses. The distribution of both measures was 
skewed and could not be normalised by transformations. The distributions were also 
leptokurtic as most observations were around zero.

The error measure of affective priming for prime-target pairs with positive targets and for 
prime-target pairs negative targets were therefore transformed into a nominal variables 
consisting of an error affective priming effect category and a no error affective priming 
effect category. The error affective priming effect category was defined for both prime-
target pairs with positive and negative targets by participants who had a greater proportion 
of errors to incongruent (+ or -) than congruent (+ or -) prime-target pairs. The no error 
affective priming effect category was defined by participants who had the same proportion 
of errors for incongruent (+ or -) and congruent (+ or -) prime-target pairs or by 
participants who had a greater proportion to congruent (+ or -) than incongruent (+ or -) 
prime-target pairs. These dichotomised measures of error affective priming with positive 
targets and error affective priming with negative targets were analysed as dependent
variables in two logistic regression analyses that included unusual experiences, impulsive nonconformity and cognitive disorganisation schizotypy dimensions as predictors.

Finally, the reaction time and error data was examined between extreme scoring high and low introvertive anhedonia groups. The analyses of affective priming with situationally unrelated conditions was conducted with 3 way mixed ANOVA’s with affective congruence (incongruent vs. congruent) and target valence (positive vs. negative) as repeated measures factors and introvertive anhedonia group (high vs. low) as the between groups factor. Simple effects analyses were conducted with both between and within group’s t-tests with the alpha values adjusted for multiple comparisons using the Bonferroni method.

### 3.4.2: Experiment 5. Results

**Demographics**

Mean ages and gender composition of the high and low introvertive anhedonia groups are presented in Table 24. According to the criteria outlined in the method section, 24 were defined as high. Being defined as high or low introvertive anhedonia was not associated with gender (p>.05 fishers exact test). These two groups also did not differ in age (t=0.544, df = 45, p>.05) (see table 24).

<table>
<thead>
<tr>
<th>Gender and age by high/low introvertive anhedonia</th>
<th>Low (n=23)</th>
<th>High (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>Male</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Age (mean/SD)</td>
<td>24.3 (6.8)</td>
<td>25.9 (12.5)</td>
</tr>
</tbody>
</table>

The high introvertive anhedonia group had higher mean unusual experiences, cognitive disorganisation and impulsive nonconformity scores than the low group. These group differences were not statistically significant for the impulsive nonconformity (t=0.211, df=45, p>.05) or the unusual experiences subscale (t=1.964, df=43.249, p>.05). However,
group differences and were statistically significant for the cognitive disorganisation (t=2.349, df=45, p<.05) subscale scores (see table 25).

<table>
<thead>
<tr>
<th>Table 25</th>
<th>O-LIFE total scores and subscale scores for the high and low introvertive anhedonia groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (n=23)</td>
</tr>
<tr>
<td></td>
<td>Mean   (SD)</td>
</tr>
<tr>
<td>Unusual Experiences</td>
<td>7.83   (5.78)</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>9.61   (4.98)</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>9.91   (3.35)</td>
</tr>
<tr>
<td><strong>Introvertive anhedonia</strong></td>
<td><strong>1.13   (0.81)</strong></td>
</tr>
<tr>
<td>O-LIFE Total</td>
<td>28.48   (10.99)</td>
</tr>
</tbody>
</table>

**Experimental analyses**

As in previous experiments erroneous responses, consisting of 6.2% of the current data set, were removed from the analyses. Short and long extreme reaction times that were defined by the same criteria as previous experiments and consisting of a further 2.4% of the current data set were also removed.

**Multiple regression analyses**

Two regression analyses examined reaction time affective priming effects for prime-target pairs with positive and negative targets.

The first multiple regression analyses examined affective priming effects for prime-target pairs with positive targets (+ minus ++) as the dependant variable with schizotypy trait dimensions that were not of direct relevance to the current investigation as predictor variables. The positive target affective priming dependant variable and the unusual experiences variable had mild skew and were both subjected to a square root transformation. All other variables appeared to be normally distributed.
The unusual experiences, impulsive nonconformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method. A significant model did not emerge (F(3,43)=0.773, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of affective priming with positive targets (RT+ minus RT++) (see appendix 1. table A1.12 for coefficients of predictors).

The second multiple regression analyses examined affective priming effects for prime-target pairs with negative targets (+- minus --) as the dependant variable with schizotypy trait dimensions that were not of direct relevance to the current investigation as predictor variables. The negative target affective priming dependant variable had one outlying case, which was removed from the analyses. The unusual experiences variable had mild skew and was subjected to a square root transformation. All other variables appeared to be normally distributed.

The unusual experiences, impulsive nonconformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method. A significant model did not emerge (F(3,42)=1.018, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of affective priming with negative targets (RT+- minus RT--) (see appendix 1. table A1.13 for coefficients of predictors).

**Logistic regression analyses**

Two logistic regression analyses examined error affective priming effects for prime-target pairs with positive and negative targets.

The first logistic regression analyses included a dichotomised measure of error affective priming effects for prime-target pairs with positive targets (+- minus ++) as the dependent variable (no positive target error priming effect category: no difference in error between +- and ++ or greater proportion of errors ++ than +- vs. positive target error priming effect category: greater proportion of errors to +- than ++) and unusual experiences, impulsive nonconformity and cognitive disorganisation as predictor variables. A total of 47 cases were analysed but a significant model did not emerge (omnibus chi-square =3.416, df = 3, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of error affective priming with positive targets (error+- vs. error++) (see appendix 1. table A1.14 for coefficients of predictors).
The second logistic regression analyses included a dichotomised measure of error affective priming effects for prime-target pairs with negative targets (± minus --) as the dependent variable (no error group: no difference in error between ± and -- vs. error group: greater proportion of errors to ± than --) and unusual experiences, impulsive nonconformity and cognitive disorganisation as predictor variables. A total of 47 cases were analysed but a significant model did not emerge (omnibus chi-square =5.603, df = 3, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of error affective priming with negative targets (error± vs. error--) (see appendix.1 table A1.15 for coefficients of predictors).

ANOVA of Reaction Time Affective Priming

Mean reaction times of the high and low introvertive anhedonia groups to affectively congruent and incongruent prime-target pairs are presented in table 26. The high introvertive anhedonia group had longer reaction time means than the low group in both congruent and incongruent conditions. Furthermore, the difference between the congruent and incongruent conditions was also smaller for the high than the low introvertive anhedonia groups. This suggests that both the high and low introvertive anhedonia groups produced an affective priming congruency effect. However, the magnitude of priming appears smaller in the high than the low introvertive anhedonia groups.

<table>
<thead>
<tr>
<th></th>
<th>Low (n=23)</th>
<th>High (n=24)</th>
<th>Total (n=47)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>Congruent</td>
<td>612 70</td>
<td>644 117</td>
<td>629 98</td>
</tr>
<tr>
<td>Incongruent</td>
<td>639 77</td>
<td>662 105</td>
<td>651 92</td>
</tr>
</tbody>
</table>

A more detailed analysis of reaction times of the high and low introvertive anhedonia groups to affectively congruent and incongruent prime-target pairs that had positive or negative targets are presented in figure 17 below. For conditions with positive targets, the
high introvertive anhedonia group were faster whilst responding to congruent than incongruent prime-target pairs. In contrast, the low introvertive anhedonia group appears to have responded with comparable speed to incongruent and congruent prime-target pairs (see Figure 17 left panel). However, for conditions with negative targets, the high introvertive anhedonia group responded with comparable speed to congruent and incongruent prime-target pairs while the low introvertive anhedonia group were faster whilst responding to congruent than incongruent prime-target pairs (see Figure 17 right panel).

Figure 17. Mean reaction times of the low and high introvertive anhedonia groups to affectively congruent and incongruent prime-target pairs with positive (left panel) and negative (right panel) targets. (error bars represent S.E. of the mean) [- = negative prime/target, + = positive prime/target]

These means were analysed in a 3-way 2 (affective congruence: congruent vs. incongruent) x 2 (target valence: positive vs. negative) x 2 (introvertive anhedonia group: high vs. low) repeated measures ANOVA. A main effect of congruence (F(1,45)=21.438, p<.001, \(\eta^2=.323\)) was found indicating that mean reaction times to congruent prime-target pairs (M=629, SE=14, CI\(_{95}\) =601, 657) significantly differed from mean reaction times to incongruent prime-target pairs (M=651, SE=.14, CI\(_{95}\) =623, 677) and is indicative of a global affective priming effect. A main effect of valence was also revealed (F(1,45)=9.929, p<.01, \(\eta^2=.181\)) indicating that positive targets (M=630, SE=14, CI\(_{95}\) =602, 658) had significantly faster mean reaction time responses than negative targets(M=650, SE=14, CI\(_{95}\) =622, 677).
The between groups portion of the ANOVA analyses revealed no main effect of introvertive anhedonia group (F(1,45)=1.017, p>.05), indicating that the high and low introvertive anhedonia groups did not have significantly different global reaction times. There was also no affective congruence by introvertive anhedonia group interaction (F(1,45)=0.922, p>.05), indicating no between groups differences in the magnitude of the global affective priming effect. There was also no valence by introvertive anhedonia group interaction (F(1,45)=0.001, p>.05), indicating no between groups differences in reaction time responses to positive and negative targets. The analyses did, however, reveal a significant 3-way affective congruence by target valence by introvertive anhedonia group interaction (F(1,45)=5.476, p<.05, $\eta^2=.108$) (Figure 17).

Post hoc analyses examining the 3-way affective congruence by target valence by introvertive anhedonia interaction tested for the presence of affective priming in the high and low introvertive groups in the conditions with positive and negative targets. It specifically sought to determine whether reaction times were significantly slower for affectively incongruent than affectively congruent prime-target pairs. Alpha was adjusted for 8 comparisons with the Bonferroni method and the critical value for significance set at .006. For the low introvertive anhedonia group the paired samples t-tests found a significant affective priming effect for prime-target pairs with negative targets ($t=4.137$, df=22, $p<.001$, Cohen’s $d=0.48$) but not for prime-target pairs with positive targets ($t=1.472$, df=22, $p>.006$). In contrast, the high introvertive anhedonia group displayed the opposite pattern of effects; that is, a significant affective priming effect for prime target pairs with positive targets ($t=3.802$, df=23, $p<.001$, Cohen’s $d=0.20$) but not for pairs with negative targets ($t=1.111$, df=23, $p>.006$). Between groups comparisons using independent samples t-test found no significant differences between the high and low introvertive anhedonia groups for either congruent means with negative ($t=1.429$, df=45, $p>.006$) or positive ($t=0.762$, df=45, $p>.006$) targets or incongruent means with negative ($t=0.494$, df=45, $p>.006$) or positive ($t=1.143$, df=45, $p>.006$).

**ANOVA of Error Affective Priming**

Affective priming in the error data was measured in the same way as affective priming in the reaction time data, that is, as a greater percentage of errors for incongruent than congruent prime-target pairs. Figure 18 below presents the mean percentage of errors of both the high and low introvertive anhedonia groups for affectively incongruent and
congruent prime-target pairs with positive and negative targets. The low introvertive anhedonia group generated a greater percentage of errors for affectively incongruent than congruent conditions for both prime-target pairs with positive and negative targets. In contrast, the high introvertive anhedonia group generated a comparable percentage of errors for incongruent and congruent prime-target pairs with positive targets but a smaller percentage of errors for incongruent than congruent prime-target pairs with negative targets.

Figure 18. Mean percentage of errors of the low and high introvertive anhedonia groups to affectively congruent and incongruent prime-target pairs with positive (left panel) and negative (right panel) targets. (error bars represent S.E. of the mean) [- = negative prime/target, + = positive prime/target]

These mean error percentages for the high and low introvertive anhedonia groups were analysed in a 2 (affective congruence: congruent vs. incongruent) x 2 (target valence: positive vs. negative) x 2 (introvertive anhedonia group: high vs. low) mixed ANOVA. It revealed no main effect of congruence (F(1,45)=2.390, p>.05), indicating that a global error affective priming effect was not present, and no main effect of valence (F(1,45)=0.814, p>.05), indicating that the percentage of errors did not differ for prime-target pairs with positive or negative targets. The analyses also found no main effect of introvertive anhedonia group (F(1,45)=1.169, p>.05) indicating no between groups differences in the percent of generated errors. However, the analyses did reveal a congruence by introvertive anhedonia group interaction (F(1,45)=6.871, p<.05, η²=.132) (see Figure 19).
Post hoc analyses used paired samples t-tests to examine the presence of an error affective priming congruency effects in the high and low introvertive anhedonia groups. The analyses specifically sought to determine whether the percentage of errors was significantly higher for affectively incongruent than congruent prime-target pairs. Alpha was adjusted for 2 comparisons with the Bonferroni method and the critical value for significance set at .025. The analyses found a significant error affective priming effect in the low introvertive anhedonia group (t=2.984, df =22, p<.025, Cohen’s d=0.68). However, the high introvertive anhedonia group did not generate an error affective priming effect (t=-0.752, df=23, p>.025).

3.4.3: Experiment 5. Discussion

Summary of Findings

A global affective priming congruency effect that did not interact with introvertive anhedonia indicates that both the high and low introvertive anhedonia groups generated an affective priming effect and that the magnitude of these effects did not differ between the groups. More detailed analyses found that the low introvertive anhedonia group displayed an affective priming effect for prime-target pairs with negative targets but not for prime-target pairs with positive targets. In a direct contrast, the high introvertive anhedonia
group displayed an affective priming effect for prime target-pairs with positive targets but not for prime-target pairs with negative targets.

No global error affective priming effect was observed. However, between groups analysis found a global error affective priming effect in the low introvertive anhedonia group but not in the high introvertive anhedonia group.

**Comment on Reaction Time Findings**

In the affective priming categorisation task, priming is observed when targets of affectively incongruent prime-target pairs take longer to evaluate and categorise as good/bad or positive/negative than targets of affectively congruent pairs. A global affective priming congruency effect was observed in the current experiment suggesting that the processing of primes influenced the processing of targets and that both primes and targets were processed affectively. This global affective priming effect was present, and of a similar magnitude, in both the high and low introvertive anhedonia groups. These results do not therefore support hypothesis 1, as the high introvertive anhedonia group did display an affective priming congruency effect. However, the results do provide support for both hypotheses 2 and 4 and suggest that both the low and high introvertive anhedonia groups process emotional cues affectively.

The presence of an affective priming effect in the high introvertive anhedonia group suggests that automatic affective processing mechanisms involved in prime processing (e.g. Greenwald et al., 1989) are intact. The absence of valence effects in high introvertive anhedonic groups with emotional Stroop stimuli (experiment 3) and in the dot probe paradigm (experiment 4) implicates, in these experiments, the active inhibition or repression of automatic affective processing mechanisms.

With reference to Bar-Haim et al. (2007) model of the cognitive mechanisms underlying threat processing (see figure 9), results from the current experiment suggests that high introvertive anhedonic groups do preattentively process stimuli affectively. Incoming stimuli is evaluated as affective and a system equivalent to Bar-Haim et al. (2007) resource allocation system (RAS) interrupts ongoing activity and allocates resources to the processing of salient emotional stimuli. The emotion processing deficit in introvertive anhedonia must therefore involve later more controlled processes of an equivalent stage to
Bar-Haim et al. (2007) guided threat evaluation system (GTES). Bar-Haim et al. (2007) suggests that the GTES makes comparison with memory, assesses context and prior learning and can override automatic processing systems of the RAS.

Under certain conditions, such as responding to emotional Stroop stimuli or under parameters of the dot probe paradigm, individuals with many introvertive anhedonic traits might make subjective judgments of incoming emotionally valenced stimuli by assessing context and prior learning. Emotional stimuli might then be judged as low in valence and preattentive automatic emotion evaluation systems might be consequently overridden. This could result in the elimination of emotional Stroop valence effects and dot probe effects. A conditional approach to automatic processes (Bargh, 1989, 1992, 1994), where automatic processes can be characterised by a set of defining features - intentional vs. unintentional, efficient vs. attention-demanding, dependent on awareness vs. not dependent on awareness and controllable vs. uncontrollable - that do not have to co-occur in an all or none fashion, provides a theoretical framework for this possibility. However, this also raises the question of why individuals with many introvertive anhedonic traits did not override the automatic emotion processing of primes in the affective priming paradigm.

The short presentation time separating the onset of prime and target (i.e. 150ms) in the affective priming paradigm might not provide sufficient time for subjective assessments of context, memory and prior learning and the overriding of automatic emotion evaluation systems. In contrast, list based effects in the emotional Stroop task (Mckenna and Sharma, 2004; Waters et al., 2003) reflect process that operate at longer intervals between stimuli (i.e. 2000ms) and might provide the necessary processing time for subjective judgments to occur and subsequent overriding of automatic emotion evaluation systems. Such an explanation does not however explain the absence of effects with the dot probe paradigm where a short but variable time (i.e. 150 and 500ms) separated the onset of cue stimuli and dot probe.

Although involving multiple processes, response competition/facilitation may be the primary mechanism involved in the affective priming categorisation task (e.g. Klauer et al., 1997) where affective prime stimuli triggers a response tendency that is either congruent or incongruent with the affective value of the target. The absence of response competition/facilitation with both emotional Stroop stimuli and in the dot probe paradigm might have prevented effects being observed in the high introvertive anhedonia group in experiments 3 and 4. The response conflict in the affective priming paradigm is likely to
increase the demands of the task and reduce the availability of processing resources to inhibit or override automatic affective evaluation systems.

Although global affective priming effects were present and comparable in the high and low introvertive anhedonia groups, there were between groups’ differences in the priming effect with targets of differing valence. The low introvertive anhedonia group produced an affective priming effect with negative targets but not with positive targets. This supports hypothesis 5 and indicates that positive primes interfered with the evaluation and categorisation of negative target but that negative primes did not interfere with evaluation and categorisation of positive targets. These results are consistent with the positive cue processing preference observed in experiment 3 with emotional Stroop stimuli and the positive cue processing bias observed in experiment 4 with the dot probe paradigm. In a direct contrast, the high introvertive anhedonia group produced an affective priming effect with positive targets but not with negative targets. This is inconsistent with hypothesis 3 that predicted comparable priming effects in the high introvertive anhedonia group for prime-target pairs with positive and negative target due to their apparent blunted emotion cue processing in experiment 3 and 4.

The results instead implicate a negative cue processing preference in the high introvertive anhedonia group that might have been undetectable whilst processing emotional Stroop stimuli and with parameters of the dot probe paradigm. As described above, effects with emotional Stroop stimuli are list based and involve a slow mechanism that operates between stimuli. The high introvertive anhedonia group might have overridden emotional cue processing during the long interval between stimuli (i.e. 2000ms) in the emotional Stroop task. However, the short interval (i.e. 150ms) separating prime and target in the affective priming paradigm might have prevented such suppression. Furthermore, neither the dot probe paradigm nor emotional Stroop involve response competition/facilitation mechanisms, which may be the primary process responsible for observing effects in the current experiment.

Additional evidence further suggests that between groups priming effects were due to idiosyncratic prime processing and not differences in the processing of targets. Independent of priming effects, reaction time responses were significantly faster to positive targets than to negative targets. This target valence effect did not interact with the introvertive anhedonia groups suggesting that between groups differences in affective
priming effects with targets of differing valence was driven by group differences in the processing of primes and not in the processing of targets.

Comment on Error findings

The absence of a global error affective priming effect suggests that errors were a less sensitive measure of the interference and facilitation generated by the compatibility or incompatibility of prime-target valence. However, between groups analysis found a global error affective priming effect in the low introvertive anhedonia group but not the high introvertive anhedonia group. While the reaction time data suggests that automatic emotion cue processing is intact in high introvertive anhedonic groups, the error data suggests that this system is comparatively blunted. The response tendency triggered by primes might have been weaker in the high than the low introvertive anhedonia group thereby not interfering sufficiently with target responding to generate an affective priming error effect. There were no global or between groups valence effects again suggesting that errors were a less sensitive measure of affective priming effects.

Methodological Problems and Limitations of the Current study

The presence of priming effects in the current study is argued to provide evidence of intact automatic emotion cue processing. However, CP effects with 150ms SOA, as used in the current study, (Klauer et al., 1997; Spruyt, Hermans et al., 2007) suggest that some controlled processing of primes occurs. For definitive conclusions of the correct functioning of automatic emotional evaluation system in negative schizotypy then primes would need to be presented below the threshold of conscious detection (i.e. <20ms, see Williams et al 2006 for discussion of subliminal emotional stimulus detection thresholds). The observation of affective priming under these conditions would suggest that primes were processed automatically without any controlled conscious processing.

A further methodological confound of the current study was that the high and low introvertive anhedonia groups were not only significantly different on levels of introvertive anhedonia but also on levels of cognitive disorganisation, the O-LIFE’s disorganised schizotypy dimension. Observed effects cannot therefore be attributed solely to levels of introvertive anhedonia or negative schizotypy. However, multiple and logistic regression
analyses indicate that reaction time and error measures of affective priming with positively and negatively valenced targets were unrelated to unusual experiences, cognitive disorganisation, impulsive nonconformity schizotypy dimensions or global schizotypy scores.

Conclusion

The experiment was successful in its primary objective. The results suggested that while automatic emotion processing mechanisms are intact in negative schizotypy, they are somewhat blunted compared to the control group. The experiment further revealed a possible negative cue processing preference in the high introvertive anhedonia group, which may have been undetectable under conditions of the emotional Stroop and dot probe tasks. The experiment also provides additional support for the processing preference of the low introvertive anhedonia group to positively valenced stimuli previously observed in experiment 3 and 4.

3.5: Interim discussion 3

The preceding experiment using the affective priming paradigm (experiment 5) addressed the aims outlined at the end of the dot probe experiment (experiment 4). It specifically sought to determine whether the absence of valence effects in high introvertive anhedonia groups in experiment 3 and 4 was due to deficits in automatic emotion processing systems. Experiment 5 specifically examined whether the high introvertive anhedonia group processed emotion cue stimuli affectively. It used an affective priming paradigm, where the affective processing of primes is thought to be automatic and unavoidable, and found an affective priming congruency effect in both the high and low introvertive anhedonia groups. This suggested that both the high and low introvertive anhedonia groups processed primes and targets affectively and further suggests that the absence of emotion cue processing valence effects in the high introvertive anhedonia groups, observed in experiment 3 and 4, was due to the active inhibition of automatic emotion cue processing. For example, effects with emotional Stroop stimuli are thought to result from the increased allocation of cognitive resources to either consciously ignore emotional stimuli or to actively disengage from processing emotional stimuli. The absence of emotional Stroop
effects might therefore implicate the preattentive or implicit inhibition of automatic emotion cue processing.

Experiment 5 further indicated that while the low introvertive anhedonia group had a positive cue emotion processing preference, the high group had a negative cue processing preference. The effects in the low introvertive anhedonia group were expected and consistent with experiment 3 and 4. However, the effect in the high group was inconsistent with experiment 3 and 4, which indicated comparable processing of positively and negatively valenced stimuli.

One possibility that might account for the absence of a positive emotion cue processing preference in high introvertive anhedonia groups is that pleasure stimuli do not have the same attention grabbing value for the high introvertive anhedonia group that they have for the low introvertive anhedonia group. Negative schizotypy might therefore be associated with a reduction in the reward value of positive stimuli. Previous studies indicate that self-reports of the amount of pleasure experienced from consuming pleasurable sensory stimuli are comparable in anhedonia and control groups (Germans and Kring, 2000; Horan et al., 2006). However, reward responsiveness in anhedonia is reduced (e.g. Applegate et al., 2009; Germans and Kring, 2000) suggesting a reduction in the expected rewarding value of positive stimuli.

Experiments 1 and 2 suggested that the high introvertive anhedonia group have a context processing deficit that might otherwise enable flexible behavioural adaptation. Such a deficit could result from, or result in, reductions in the reward value of positive stimuli. Reductions in the expectation of reward value of positive stimuli might reduce the ability of positive stimuli to enter into stimulus response associations during learning. This would subsequently result in difficulties to respond flexibly to new and changing situations. On the other hand, an underlying disruption in the ability to form, strengthen or maintain the contextual representations that guide behaviour might result in positive stimuli not acquiring high reward value.

The following experiment will therefore attempt to determine whether the context processing deficit in high introvertive anhedonia is caused by, or results from, reductions in the processing of positive emotion cue stimuli. It will therefore address objective 3 of the thesis by exploring the possibility of interactions between executive functioning and emotion cue processing in negative schizotypy. It will specifically examine the impact that
positive and negative valenced stimuli have on reinforcement learning by analysing the acquisition of biconditional discriminations and subsequent responses to positive and negative predication error. These procedures will enable the examination of the ability of valenced outcomes to support the development of the contextual representations that guide behaviour and the ability of positive and negative valenced outcomes to support new error driven learning.
Chapter 4:

Synthesis: Cognitive Processes and Emotion Cue Processing in Introvertive anhedonia
4.1: Experiment 6. Biconditional Discrimination

The preceding 5 experiments have addressed objective 1 and 2 of the thesis by exploring the possibility of an executive deficit in introverted anhedonia, and by exploring the possibility of an emotion cue processing deficit in the introverted anhedonia. Experiment 1 and 2 (presented in Chapter 2) found evidence indicating that high scoring introverted anhedonics have an executive functioning abnormality that could be characterised as a context processing deficit. Experiments 3, 4 and 5 (presented in Chapter 3) also found evidence of an emotion cue processing deficit in high introverted anhedonia that was characterised, in most situations, as an inability to differentiate between positively and negatively valenced emotional cues and in one situation under certain specific conditions, a preference to the processing of negatively valenced emotional cues. The following experiment will therefore address objective 3 of the thesis by exploring whether executive functioning and emotion cue processing deficits interact.

Several lines of evidence indicate that learning is impaired in schizophrenia and schizotypy. Latent inhibition effects are typically reduced or abolished (e.g. Gray et al., 2004), blocking effects attenuated (e.g. Moran et al., 2007) and the acquisition of conditional discriminations is impaired (Haddon, George, Grayson, McGowan, Honey and Killcross, in press). The following discussion will consider each of these effects and the most prevalent accounts for their disruption in schizotypy and schizophrenia. It will become clear that despite a number of propositions for disrupted learning in schizotypy, none consider the influence of outcome valence. There is evidence suggesting that the emotional valence of unconditioned stimuli is a critical component that influences the acquisition of associations by driving prediction error signalling (e.g. Schultz, 1998). This experiment will therefore examine the influence of positive and negative valenced outcomes during the acquisition of biconditional discriminations. It will also examine the strength of these associations and the differential ability of valenced outcomes to support new learning by generating positive and negative prediction error during a revaluation stage.
Latent inhibition

The Latent inhibition (LI) effect is the observation that learning about a stimulus-outcome association is impaired when the stimulus has previously been presented without a consequence (see table 27). The most prevalent account of LI is that the irrelevance of a stimulus is learned during a pre-exposure phase when the stimulus is presented without a consequence (A-). Learning a new association when the stimulus predicts a consequence (A+) during a test phase is subsequently impaired as processing of the stimulus is inhibited. Such accounts essentially propose an attentional mechanism whereby pre-exposure to a stimulus without an outcome results in less attention being paid to it when it is presented with an outcome.

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<th>Table 27</th>
<th>Stages resulting in the LI effect</th>
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<td></td>
<td>Pre-exposure Phase</td>
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<td>A-</td>
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An abolition of the LI effect is frequently demonstrated in patients during acute psychotic phases of a schizophrenia illness (e.g. Baruch, Hemsley & Gray, 1988a; Gray, Pilowsky, Gray & Kerwin, 1995). This is interpreted as a failure in schizophrenia to gate sensory information and inhibit the processing of the pre-exposed stimuli during the learning phase. Similar effects are also reported in the positive trait dimensions of schizotypy (e.g. Baruch, Hemsley & Gray, 1988b; Gray et al., 2004). More recently, Shrira and Tsakanikos (1999) observed bi directional LI effects in schizotypy with LI being attenuated in positive schizotypy but enhanced (i.e. a super LI effect) in negative schizotypy. This is consistent with a super LI effect in the negative symptoms of schizophrenia (Rascle et al., 2001; Cohen et al., 2004) and suggests that opposing processes might be associated with positive and negative symptoms. Presuming that learning a stimulus no outcome association in the pre-exposure phase occurs in comparable ways, then the results of Shrira and Tsakanikos (1999) suggest that the absence of LI in the positive trait/symptoms might reflect a deficit in inhibiting the processing of the stimulus in the learning phase, whereas a supper LI effect in the negative trait/symptoms might reflect a deficit in forming new associations.
Blocking

The Blocking effect (Kamin, 1969) results from conditioning a stimulus with an outcome (A+), which subsequently blocks learning of a new stimulus outcome association (Y+) when that stimulus is presented in compound with the previously conditioned stimulus (AY+) (see table 28). Formal accounts of associative learning (e.g. Rescorla and Wagner, 1972) explain such effects by presuming that once a stimulus fully predicts an outcome (A+), and is at asymptote, then its subsequent presentation in a compound with a novel stimulus (AY+) will not support new learning of the novel stimulus (Y) as the outcome is already fully predicted by the previously conditioned stimulus (A+). Such accounts might also implicate an attentional mechanism where the acquisition of the A→outcome association results in the inhibition of processing the novel stimulus Y as the novel stimulus does not increase the associative AY→outcome relationship beyond that already predicted by A. Essentially, the Y stimulus is perceived as irrelevant and attention to it is inhibited.

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<th>Table 28</th>
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<tr>
<td>Stages and outcome of the blocking paradigm (Kamin, 1969)</td>
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<tr>
<td>Stage 1</td>
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<td>A+</td>
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<td>B-</td>
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A number of studies indicate that the blocking effect is attenuated or abolished in patients with a diagnosis of schizophrenia. Furthermore, the absence or attenuation of blocking has been found to be associated with both positive symptoms (Jones, Gray & Hemsley, 1992; Jones, Hemsley, Ball & Serra, 1997; Moran, Al-Uzri, Watson and Revelly, 2003) and negative symptoms (Bender, Mullerab, Oadesb & Sartorvc, 2000; Moran et al., 2007). Disrupted blocking in schizophrenia has been interpreted as reflecting deficits in the same attentional system that results in an absence of the LI effect. A failure in schizophrenia to gate out or inhibit the processing of irrelevant stimuli could result in an absence of blocking. If the initial stimulus outcome association is acquired in stage 1 then a failure in schizophrenia to gate out or inhibit the processing of the novel but irrelevant stimulus Y would result in an acquisition of a Y→outcome association and an absence of blocking during the test phase.
Haselgrove and Evans (2010) propose an alternative explanation and suggest that attenuation in blocking in negative schizotypy is due to variations in selective (e.g. Rescorla & Wagner, 1972) and non-selective (e.g. Bush & Mosteller, 1951) prediction error. Prediction error is a major component of a number of formal accounts of associative learning (e.g. Rescorla & Wagner, 1972; Mackintosh, 1975; Pearce & Hall, 1980). It is the mismatch between expectancy and experience that is thought to underpin the change in the strength of associations. Blocking is thought to result from a selective prediction error (e.g. Rescorla & Wagner, 1972) where the change in the association strength of a cue is influenced by the associative strength of cues that accompany it. Essentially, selective prediction error is calculated as the discrepancy between asymptote and the sum of the association strength of all cues present on a given trial. In the case of blocking, when AY+ is presented in stage 2 then the sum of the association strength of all cues will equal the association strength of A, which reached asymptote during training in stage 1. The prediction error in stage 2 will therefore be very small and will not support any new learning of Y. Haselgrove and Evans (2009) suggest that an attenuation in blocking in negative schizotypy is due to an increased reliance on non-selective prediction error (e.g. Bush & Mosteller, 1951) where changes in the associative strength of a cue is not influenced by other cues that accompany it. Essentially, non-selective prediction error is calculated as the discrepancy between asymptote and the associative strength of each cue present on a given trial. Blocking would therefore not occur because when AY+ is presented in stage 2, the discrepancy between the association strength of Y and asymptote is large and a new association between Y and the outcome is supported.

Haselgrove and Evans (2009) tested their hypothesis by using procedures described by Rescorla (2000) that provide a measure of non-selective prediction error. Rescorla (2000) demonstrated that when one stimulus was trained as a predictor of an outcome (A+) and another stimulus trained in a compound as a predictor of the absence of an outcome (XB-) then subsequent presentation of two stimuli with differential training histories in a compound followed by a an outcome (AB+) resulted in cue B undergoing greater association strength change than cue A. Rescorla (2000) argued that such results could only be explained by a non-selective predication error where the change in the cues association strength occurs independently of the cue that accompanies it. Cue B undergoes greater associative strength change than cue A when the cues are presented in a reinforced compound (AB+) because the discrepancy, or prediction error, between the current predictive strength of B- and reinforced asymptote is larger than the same discrepancy, or prediction error, between A+ and reinforced asymptote. Essentially, learning of the
components of the compound stimulus (AB) is asymmetrical as association strength of stimuli B changes more than stimuli A. Using these experimental procedures Haselgrove and Evans (2009) found that while groups scoring highly on introvertive anhedonia display this asymmetrical learning about the components of a compound stimulus, groups scoring low on introvertive anhedonia did not.

Haselgrove and Evans (2009) therefore report a double dissociation. The low introvertive anhedonia group but not the high in introvertive anhedonia group displayed a blocking effect (Kamin, 1969), which is indicative of the low introvertive anhedonia groups use of a selective learning mechanism (e.g. Rescorla and Wagner, 1972). In contrast, those high but not low in introvertive anhedonia displayed asymmetrical learning about the components of a compound stimulus (Rescorla, 2000), which is indicative of the high introvertive anhedonia group’s use of a non-selective learning mechanism (e.g. Bush and Mosteller, 1951). Such dissociations suggest that those scoring high on introvertive anhedonia learn in a more elemental way that does not take account of accompanying stimuli. Such a learning style has implications for the way in which conditional discriminations are acquired. This will be elaborated upon in the following discussion.

**Conditional discriminations**

The acquisition and successful performance of conditional discriminations involves learning a conditional rule of the predictive value of a compound stimulus. In a typical conditional discrimination task a correct lever press for reward (i.e. lever right =Y or lever left = X) is disambiguated by (or conditional on) a preceding stimulus (A or B) such that combinations of stimuli A-Y and B-X predicts an outcome whereas A-X and B-Y predict no outcome. Successful performance of conditional discriminations is thought to involve the ability to construct, maintain and update contextual representations in order to guide behaviour (e.g. Dunn, Futter, Bonardi & Killcross, 2005 for discussion). Such representations might consist of the rules (i.e. ‘if A then Y = outcome’ or ‘if A then X = no outcome and ‘if B then X = outcome’ or ‘if B then Y = no outcome) that provide the context by which the predictiveness of a combination of arbitrary stimuli can be disambiguated.

Deficits in the ability to construct, maintain and update context representations can account for difficulties demonstrated by people with a diagnosis of schizophrenia in a variety of
tasks thought to be mediated by functions of the prefrontal cortex (Cohen & Servan-Schreiber, 1992). For example, a weakening in the ability to maintain Stroop task instructions is thought to result in the decreased colour naming and increased word reading that accounts for Stroop task performance in participants with a diagnosis of schizophrenia (Barch et al., 2004). A further example is the degraded performance of patients with a diagnosis of schizophrenia on the AX version of the continuous performance task (AX-CPT) (Barch, Carter, MacDonald, Braver & Cohen, 2003). In this task, stimuli are continuously presented and participants are required to respond to an X only when it is preceded by an A. The preceding cue A is thought to provide the context that disambiguates a correct response from an incorrect response when stimulus X is presented.

Contextual representations, such as the ‘if then’ rules in conditional discriminations, instruction in the Stroop task and the A in the AX-CPT, are thought to bias the allocation of cognitive resources to the demands of a task and can be conceptualised as the application of top down cognitive control (Miller & Cohen, 2001). Consistent with findings of experiment 1 and 2 of the current thesis, introvertive anhedonia (negative schizotypy) is associated with poor performance in the acquisition of biconditional discriminations but normal acquisition of a simple discrimination (Haddon, et al., in press). These findings were interpreted as evidence of a deficit in negative schizotypy to use context information to guide behaviour. In this instance, however, context was considered to be provided by a task setting cue that disambiguates a correct from an incorrect response. Similar to the cue A in the AX-CPT task, the task setting cues in the biconditional discrimination was argued to be elements of the discrimination. For example, when A→X = allergy but A→Y = no allergy and when B→X = no allergy but B→Y = allergy then the predictive value of X and Y are conditional on the preceding cue A and B. Stimulus A and stimulus B are therefore thought to be task setters that provide the context by which the predictive value of stimulus X and stimulus Y are disambiguated. Haddon et al., (in press) further argued that because the task setting cues were present on every trial then the deficit in introvertive anhedonia was specifically an inability to use context information rather than an inability to maintain that information in working memory.

A task setting account of the successful performance of biconditional discriminations can be viewed as involving the acquisition of 4 associations (i.e. X = allergy, Y = no allergy, X = no allergy and Y = allergy) with the preceding cues A and B behaving like a switch that provides excitation to the correct association on any given trial. However, these task-
setting cues might also provide the basis by which ‘if then’ conditional rules are formed in memory. Once these conditional rules are formed then, like Stroop task instructions, their representations would provide the basis for directed behaviour. Haddon et al.’s (in press) findings might therefore reflect a deficit in negative schizotypy to 1) use task setting or contextual cues to initially guide behaviour during the early stages of biconditional discriminations, 2) a deficit to use these cues to form ‘if then’ conditional rules or, 3) a disability to maintain or strengthen these contextual representations.

Task setting or context processing accounts is not the only explanations of poor acquisition of conditional discriminations. It can also be explained by Haselgrove and Evans’ (2009) proposition that high scoring introvertive anhedonics are more reliant on a non-selective learning mechanism where the learning of cue outcome associations is not influenced by other cues present on any given trial. When A→X = outcome but A→Y = no outcome and B→X = no outcome but B→Y = outcome, then the acquisition of any one binary cue outcome association would prevent the discrimination from being solved. If, for example, the Y→ no outcome association is acquired then this will enable the half of the discrimination that involves cue A to be solved but will prevent the acquisition of the other half and the discrimination that involves cue B. Furthermore, random presentation of all the elements of the biconditional discrimination will prevent any one binary association reaching asymptote and therefore even disrupt the acquisition of one half of a biconditional discrimination.

The reliance on non-selective learning mechanisms would also predict poor performance on simple discrimination tasks when, for example, AX = outcome but AY = no outcome and BX = outcome but BY = no outcome. Here, X and Y are predictive but the acquisition of an A→ outcome association would prevent the formation of an A→ no outcome association or the acquisition of B→ outcome would prevent the formation of B→no outcome. Again, random presentation of all the elements of the simple discrimination would prevent any one binary association reaching asymptote and even disrupt the acquisition of one half a simple discrimination. However, the acquisition of simple discriminations in introvertive anhedonia appears to proceed normally (Haddon, et al., in press) suggesting that processes other than a reliance on non-selective prediction error are responsible for disrupted performance of conditional discriminations.

Another explanation of poor acquisition of conditional discriminations suggests that combinations of stimuli result in the formation of configural representations (e.g. Pearce,
1994) or unique cues (Wagner and Rescorla, 1972). For example, the presentation of compounds consisting of stimulus A and stimulus X that predict food will generate a higher level configural representation (A-X) or a unique cue stimulus (P), which is then associated with an outcome. A disability, in introvertive anhedonia, to create these unique cues or configural representations or of these to form associations would result in poor acquisition of conditional discriminations but not simple discriminations. For example, a biconditional discrimination consisting of AX→outcome, AY→no outcome and BX→no outcome, BY→outcome would require the generation of four unique cues or configural representations for its solution. However, a simple discrimination consisting of AX→outcome but AY→no outcome and BX→outcome but BY→outcome would not require either a unique cue or configural solution as cue X and Y are always predictive of the outcome making cue A and B redundant. A unique cue or configural solution therefore provides a plausible explanation for Haddon et al. (in press) who report poor acquisition of biconditional discriminations in introvertive anhedonia but the normal acquisition of simple discriminations.

Recent connectionist analyses of conditional learning suggest that unique cues or configural representations are insufficient to account for the associative structures of conditional discriminations. Rather, conditional learning can be best accounted for by a 3-layer network (Honey & Ward-Robinson, 2002; see figure 20) where a layer of input units feed into a second layer of hidden units which in turn are connected by reciprocal links to a third layer of output units. Evidence for such a structure comes from the observation that following the acquisition of conditional discriminations where AX and BX → food and AY and BY → no food but CX and DX → no food and CY and DY → food then subsequently pairing A with food and C with no food results in B eliciting greater conditioned responding than D (see Honey & Watt, 1998, 1999; Ward-Robinson & Honey 2000). Such observations are inconsistent with configural (e.g. Pearce, 1994) or unique cue (e.g. Wagner & Rescorla, 1972) accounts which argue that configural representations and unique cues are formed of stimuli that have actually been presented (e.g. A-X or B-X) but not elements of such compounds (e.g. A and B). Accordingly, after the discrimination described above has been acquired then the presentation of A→food and C→no food should form new unique associations and not generalise to B.
The connectionist analysis suggests that through a process of redundancy compression and predictive differentiation (e.g. Gluck & Myers, 1993) stimuli that predict the same outcome become grouped together. For example, two similar patterns of input (AX and BX) will come to activate the same hidden unit (p) when they are trained to predict the same outcome (e.g. food). Honey (2000) proposed that before the acquisition of the conditional discrimination the links from input units to hidden units are random. When excitation occurs between elements (e.g. A and X), a hidden unit (e.g. p) and an outcome (e.g. food), then a reciprocal link forms from the outcome back to the hidden layer. This reciprocal link provides additional excitation to the hidden layer and can be conceptualised as the feedback component of prediction error that provides information about the amount of association strength supported by a reinforcer. Once this reciprocal link has formed, the subsequent presentation of food could therefore activate hidden unit p thereby enhancing activity on the food→p feedback link and maintain the links that are necessary for input node A and X to be linked to p. As such, other compounds (e.g. B-X) that have some tendency to activate different hidden units (e.g. p and q) but signal the same outcome as A-X will become linked to the same hidden unit as A-X (i.e. p). Honey (2000) suggested that the degree to which the presentation of an outcome results in feedback declines as the...
presentation of compounds (e.g. A-X) becomes increasingly able to activate the correct hidden unit (i.e. p) thereby placing the output node (i.e. food) into a state of reduced activation referred to, in Wagner’s (1981) sometimes opponent process (SOP) model, as the A2 state.

The explanations of the poor acquisition of conditional discriminations in introvertive anhedonia considered thus far highlight (1) a possible deficit in processing context or task setting cues, (2) a reliance on non-selective rather than selective prediction error and (3) possible deficits in forming unique cues or configural representations or (4) a deficit of those cues/representations to form associations. The precise mechanism underpinning the poor acquisition of conditional discriminations in introvertive anhedonia is therefore uncertain. Furthermore, existing accounts have ignored the possibility that deficits in processing or responding to the emotional content of trial outcomes (USs) can influence the acquisition of conditional discriminations. Preceding experiments of this thesis have uniformly indicated asymmetry in responses to positively and negatively valenced cues in the low introvertive group and, in most cases, undifferentiated responding to this important aspect of stimuli in the high introvertive anhedonia group. Such blunted emotion cue processing (see experiment 3 and 4) could reduce the effectiveness of valenced outcomes as reinforcers thereby influencing the acquisition of conditional discriminations. There is evidence suggesting that the emotional valence of unconditioned stimuli is a critical component that affects the acquisition of associations by influencing prediction error signalling (e.g. Schultz, 1998). A three layer connectionist account of conditional discriminations that incorporates principles of Wagner’s (1981) SOP model and represents both appetitive and aversive outcomes provides a parsimonious framework to analyse the contribution of feedback from outcomes of opposing valence in the acquisition of conditional discriminations.

The following discussion will consider the evidence indicating that outcome valence is a critical component influencing prediction error signalling and then outline the goals and predictions of the current experiment.

**Prediction error signalling**

As highlighted above, prediction error is characterised as the mismatch between expectancy and experience and is a major component of a number of formal accounts of
associative learning (e.g. Rescorla & Wagner, 1972; Mackintosh, 1975; Pearce & Hall, 1980). In general, the occurrence of a surprising or unpredicted event generates a prediction error and supports learning. The omission of a predicted reinforcer generates negative prediction error and leads to a reduction or extinction of learning. If the reinforcer is fully predicted then the occurrence of the reinforcer is expected and learning stops. The Rescorla and Wagner (1972) rule, for example, assumes that prediction error directly influences the formation and strengthening of associations on each learning trial and is formalised as:

$$\Delta V = \alpha \beta (\lambda - \Sigma V)$$

The equation represents the change in association strength on a learning episode as $\Delta V$ with $\alpha$ and $\beta$ as constants that determine the rate of learning and reflect properties of the stimulus and reinforcer respectively such as their salience. Prediction error is represented as the $(\lambda - \Sigma V)$ component of the model with $\lambda$ representing the absolute amount of association strength supported by a reinforcer and $\Sigma V$ representing the combined association strength of all signals present on a learning episode.

The dopamine system was originally thought to contribute to reinforcement learning by mediating the feelings of satisfaction on receiving a reward (Wise, Spindler, DeWit & Gerber, 1978). However, this hypothesis has since been rejected (Wickelgren, 1997) as dopamine neurons of the midbrain respond phasically to stimuli in a way that is consistent with the differential encoding of positive and negative prediction error (see Schultz, 1997, 1998, 2002; Schultz, Dayan & Montague, 1997; Schultz & Dickinson, 2000; for reviews). During learning, dopamine neurons activate at the presentation of reward. These activations are inversely related to the progress of learning (Hollerman & Schultz 1998) suggesting that dopamine neurons code reward unpredictability in a quantitative way. Once the task is learnt, and the reward is fully predicted, then the presentation of reward no longer elicits the dopaminergic response. Rather, the conditioned stimulus produces this activity. When the task is learnt and the stimulus fully predicts the reward then midbrain dopamine neurons become active in anticipation of reward (Romo & Shultz; 1990; Ljunberg, Apicella & Schultz 1992; Shultz, Apicella & Ljunberg, 1993; Hollerman & Schultz 1998). If the predicted reward fails to occur then dopamine neuron activation depresses below baseline at the time when the reward would have occurred (Hollerman & Schultz, 1998) (see figure 21 panel 1).
Figure 21. Activations and depressions of midbrain dopamine neurons to appetitive, aversive and neutral outcomes during stages of a learning episode. When rewards are not predicted then their presentation causes dopamine neurons to excite (1a). However when the task is learnt, dopamine neurons activate at the presentation of appetitive conditioned stimuli (1b). Omission of expected rewards thereby generates a negative prediction error and cause dopamine neurons to depress below baseline at the time when the reward was expected (1c) (e.g. Hollerman & Shultz, 1998). The absence of a reward fails to excite neurons (2a) (Waelti et. al., 2001), however, dopamine neurons respond bi-phasically (activation-depression) to neutral stimuli that predict the absence of a reward when the stimuli are conditioned in alternate trials with reward predicting stimuli (2b) (Shultz & Romo 1990; Waelti et. al., 2001). Furthermore, neurons excite when a reward is presented at the time when no reward was predicted (2c) (Waelti et. al., 2001). In contrast, when an aversive outcome is not predicted then dopamine neurons depress below baseline (3a) (Schultz & Romo, 1987). When the task is learnt, then the aversive conditioned stimulus causes neurons to depress (3c) (Guarraci & Kapp, 1999; Mirenowicz & Schultz, 1996). It can be hypothesised, based on the pattern of dopamine neuron activity to appetitive and aversive outcomes, that the omission of an expected aversive outcome that generates a positive prediction error, would cause dopamine neurons to excite at the time when the punishment was expected (3c).
The response of dopamine neurons to rewards therefore depends on the mismatch between expectancy and experience (dopamine response = reward occurred – reward predicted) and represents an error in the prediction of reward that is analogous to the error term ($\lambda - \Sigma V$) in formal accounts of associative learning (see equation 1). A positive dopamine signal is generated when events are better than predicted (i.e. positive prediction error) and a negative dopamine signal, coded as a depression in activity, is generated when events are worse than predicted (i.e. negative prediction error).

Wagner’s (1981) SOP model provides a framework that reflects the activity of dopamine neurons during the acquisition of associations. Wagner (1981) proposes that stimuli are represented by nodes in associative memory. Nodes consist of a number of elements, which can exist in three states: a state of inactivation and a primary and secondary state of activation. Inactive nodes are considered to be in long term store. The primary state of activation (A1) is analogous to the focus of attention whereas the secondary state (A2) is analogous to working memory. When a cue or outcome is unexpectedly presented a proportion of the elements of a corresponding node are thought to move from a state of inactivation to the primary A1 state of activation. These elements rapidly decay from the A1 into the A2 state of activation and eventually return to a state of inactivation. It is assumed that nodes can only be in one state at a given time and that they cannot move directly from the A2 to the A1 state. When nodes of two stimuli (e.g. Y and X) are concurrently in the A1 state of activation then an associative connection is formed (Y→X). The subsequent activation of a node by an associative connection bypasses the A1 state and leads directly to A2. The presentation of stimulus Y will therefore generate the A2 state of activation in a proportion of X’s elements. This reduction in activation of elements of a predicted stimulus from a primary A1 state to a secondary A2 parallels dopamine neuron activation during stages of associative learning. When midbrain dopamine neurons are activated by the reinforcer during the initial stages of a learning episode then the reinforcer is in the focus of attention and is at the A1 state of activation. When the association is learnt and the conditioned stimulus elicits dopamine neuron activation then the reinforcer can be said to be in marginal working memory and is at the A2 state of activation.

Activation of midbrain dopamine neurons is consistent with basic assumptions of formal learning theory that is described in Wagner’s (1980) SOP model. For example, Waelti, et al. (2001) recorded midbrain dopamine neuron responses of a rat during stages of a blocking paradigm (Kamin, 1969; see table 28) and found that during all stages of the
experiment the rat’s behaviour was consistent with theoretical accounts of blocking and activations of midbrain dopamine neurons mirrored the predictive reward value of cue stimuli.

Waelti et al. (2001) also examined neuronal responses during the generation of positive and negative prediction error. After an initial training phase (table 28, stage 1), stimulus A predicted an outcome and its presentation elicited neuronal activation. Stimulus B, however, did not predict an outcome and its presentation did not elicit a response from dopamine neurons. Presenting A with no reward therefore generated a negative prediction error that was evidenced by deactivation of dopamine neurons below baseline at the time when the reward was usually presented. In contrast, presenting stimulus B with a reward generated a positive prediction error, which was evidenced by increased activation of dopamine neurons at the time of the reward. Dopamine neurons therefore appear to be involved in the prediction of the occurrence or absence of reward.

The dopamine neuron activity during the generation of positive and negative prediction error can also be described in a recent modification of Wagner’s (1981) SOP model. The modified model (MSOP: Dickinson and Burke, 1996 see also Aitken and Dickinson, 2005) proposed to account for retrospective revaluations in causal learning, suggests that excitation of associations can occur whenever elements of two nodes are in the same state (see table 29).

<table>
<thead>
<tr>
<th>Table 29</th>
<th>The modified SOP (MSOP) model (Dickinson and Burke, 1996)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outcome Element State</td>
</tr>
<tr>
<td>Cue Element state</td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td></td>
</tr>
</tbody>
</table>

Ex= excitatory learning, In= inhibitory learning.

If cue and outcome are both in the A1 or A2 activation states then excitation of association occurs. If, however, cue and outcome are in opposing states of activation (i.e. A1→A2 or A2→A1) then inhibition of the association occurs (table 29). The match and mismatch between the two states of activation is analogues to positive and negative prediction error. When cues and outcomes are novel and in the A1 state of activation then positive
prediction errors occur and support learning. However, when the cue is predictive and its elements are in the A2 state, it drives elements of the outcome node directly into the A2 state. If the outcome is then omitted then negative prediction error is generated and inhibits learning.

Whether prediction errors are equally involved in aversive learning is uncertain. Waelti et al. (2001), for example, used reward and the absence of reward to illustrate the concordance between neuronal activation and formal learning theory. In typical conditioning experiments animals are hungry when trained and it is assumed that the presentation of food is rewarding and therefore excitatory but the absence of food elicits frustration and as such is aversive and inhibitory. The absence of food may indeed be frustrating; however, dopamine neuron outputs seem to code the absence of food as a neutral non-rewarding outcome rather than an aversive outcome (see figure 21, panel 2). During initial training when the absence of reward had neither positive nor negative value Waelti, et al., (2001) observed that dopamine neurons were activated by the presentation of reward but remained at baseline when the no-food outcome was used. In contrast, most studies report that aversive stimuli, including an air puff to the hand, saline solution to mouth and an intense pinch, inhibit dopamine neuron activation below baseline (Mirenowicz & Shultz, 1996; Schultz & Romo, 1987; Ungless, Magill & Bolam, 2004) and suggest that the absence of food is not coded in the same way as an aversive outcome. Furthermore, Waelti et al. (2001) found that most dopamine neuron responses to conditioned stimuli that predicted a no-food outcome followed a bi-phasic pattern of activation (see also Schultz & Romo, 1990). Dopamine neurons were excited and were then immediately inhibited below baseline (see figure 21, panel 2) and might reflect response generalisation from the reward predicting stimuli (Mirenowicz and Shultz, 1996). Dopamine neuron activations therefore appear to discriminate between stimuli that predict a reward, stimuli that predict a punishment and stimuli that predicts the absence of reward allowing neutral outcomes to be coded and used as a learning signal (see figure 21)

It is argued that the absence of food during typical experiments of animal conditioning is a negative outcome as it elicits frustration. Its representation may indeed be encoded and used during learning. However, signals omitted by midbrain dopamine neurons suggest that no-food outcomes are uniquely encoded as a neutral stimulus. A negative prediction error was therefore generated in Waelti et al. (2001) study with stimuli of positive value (i.e. predictive of food) and an outcome of negative value (i.e. the omission of food when its occurrence is predicted) while a positive prediction error was generated with stimulus of
neutral value (i.e. predictive of no-food) and an outcome of positive value (i.e. the presentation of food when none is expected).

This analysis indicates that outcome valence is a crucial component in prediction error signalling. If dopamine neuron activations signal the mismatch between expectancy and experience in a manner that is analogous with the prediction error component of formal learning rules, represented by $(\lambda - \Sigma V)$ (see equation 1), then the size of the dopamine neuron prediction error signal would be influenced not only by the predictive value of the outcome but also by the current predictive value of the conditioned stimulus. Rescorla (2000) recently demonstrated that the changes in the association strength that stimuli undergo during revaluation occur as a negatively accelerated function. For example, when two stimuli with differential training histories (e.g. A+ and B-) are reinforced in a compound (AB+) then stimulus B undergoes greater associative strength change than stimulus A. Negative acceleration of association change also occurs when such a compound is non-reinforced (i.e. AB-) (Rescorla, 2000) where stimulus A undergoes greater associative change than stimulus B. On a given trial, therefore, the greater the negative predictive value of a stimulus and the greater the appetitive value of an outcome then the larger the generated positive prediction error will be. Following this logic, the greater the positive predictive value of a stimulus and the greater the negative value of the outcome then the larger the generated negative prediction error will be. The accurate assessment of the behavioural responses and the generation of “true” positive and negative prediction error would therefore require that both the current predictive value of stimuli and the value of the outcome be controlled. In order to generate positive and negative learning signals of the same magnitude then the current predictive value of stimuli and the value of outcomes should have equally positive or negative valence values.

**Synthesis and aims of the current study**

Schizophrenia and schizotypy are associated with deficits in learning including attenuated blocking and latent inhibition effects, which might reflect failures to inhibit or gate out irrelevant stimuli. These deficits appear to be primarily associated with the positive aspects of schizophrenia and schizotypy. However, negative schizotypy also appears to associated with deficits in learning that are characterised by poor acquisition of conditional discriminations. Explanations of such a deficit in negative schizotypy highlight a possible disability in (1) processing task setting cues, (2) a reliance on non-selective rather than
selective prediction error, (3) a possible deficits in forming unique cue or configural representations or (4) a deficit of those cues/representations to form associations. However, existing accounts ignore the possibility that deficits in processing the emotional content of trial outcomes (USs) can influence the acquisition of associations and conditional discriminations. There is evidence suggesting that the emotional valence of the unconditioned stimuli is a critical component that affects the acquisition of associations by influencing prediction error signalling (e.g. Schultz, 1998). Previous experiments of this thesis indicate that high introvertive anhedonics are associated with undifferentiated processing of positively and negatively valenced cues (see experiment 3 and 4). This could reduce the effectiveness of appetitive and aversive outcomes as reinforcers. A three layer connectionist account of conditional discriminations that represents both appetitive and aversive outcomes and that incorporates principles of Wagner’s SOP model provides the most parsimonious framework to analyse the contribution of feedback from outcomes of opposing valence in the acquisition of biconditional discriminations and during the occurrence of positive and negative prediction errors.

The current experiment will therefore address three research questions. 1. Does outcome valence differentially influence executive cognitive processes involved in the acquisition of a conditional discrimination in high and low introvertive anhedonia? 2. Are high and low introvertive anhedonic groups differentially sensitive to positive and negative prediction errors? 3. Do high scoring introvertive anhedonic participants have a greater tendency to process elements?

A task setting account of the disrupted acquisition of conditional discriminations is consistent with experiment 1 and 2 of this thesis and also a number of observations of a context processing deficit in schizophrenia (e.g. Barch et al., 2003). In Haddon et al.’s (in press) study the acquisition of the discrimination proceeded hierarchically where two specific cues (A and B) represented by meat products acted as task setters with the other elements of the discrimination (X and Y) represented by fruit and vegetable products. Representing all elements of a biconditional discrimination by the same type of stimulus and presenting them randomly might reduce the likelihood that task setters will be used to acquire the discrimination and should increase the influence of the valence of outcomes in acquiring the discrimination. This procedure would therefore enable a more sensitive means of examining the influence of differential emotion cue processing on executive functions involved in constructing, maintaining and updating context representations in groups scoring high and low on introvertive anhedonia. Examining the acquisition of
conditional discriminations with outcomes that are of equal valence on a positive/negative dimension would provide a means of testing the effects of outcome valence in the construction, maintenance and updating of the contextual rules that guide behaviour.

Such a procedure would also enable the examination of ‘true’ positive and negative prediction errors, and the immediate behavioural consequence of appetitive and aversive outcomes to support new learning, by partially reversing the predictive outcomes of the discrimination in a subsequent revaluation stage. A negative prediction error would be generated by presenting an aversive outcome when an appetitive outcome was predicted, presumably activating dopamine neurons in a manner illustrated in figure 21 panel 1c. Conversely, a positive prediction error would be generated by presenting an appetitive outcome when an aversive outcome was predicted in a manner illustrated in figure 21 panel 3c (see method for greater detail).

A partial revaluation that simplifies the discrimination would also enable the examination of high and low introvertive anhedonic groups’ differential abilities to learn about elements (Haselgrove and Evans, 2010). A partial revaluation of a biconditional discrimination consisting of AX→allergy, AY→no allergy and BX→no allergy, BY→allergy such that AX→allergy but AY→no allergy and BX→allergy but BY→allergy would mean that X and Y would become predictive of the outcome making cue A and B redundant. More confident ratings of the predictive value of elements X and Y would imply a greater tendency to process elements X and Y.

**Predictions and hypotheses**

Stage one of the experiment will reduce the likelihood that task setters are used in the solution of a biconditional discrimination and examine whether outcome valence differentially influences the acquisition of a biconditional discrimination in high and low introvertive anhedonia. If preferences in the processing of valenced stimuli influence the process by which associations are formed, or by which these associations form the basis of the contextual rules that guide behaviour, then differences in the acquisition of the biconditional discrimination might be expected between groups that have different processing preferences for valenced stimuli. A processing preference to positive stimuli might increase the salience of an appetitive outcome, represented by $\beta$ in the Rescorla-Wagner rule (see equation 1), and ease the formation of associations between cues and
appetitive outcome thereby facilitating the formation of contextual rules. Low introvertive anhedonic groups have consistently displayed a processing preference to positive stimuli in the emotional Stroop, dot probe and affective priming experiments (experiments 3, 4 & 5) presented earlier in this thesis. It would therefore be predicted that the low introvertive anhedonia group would display enhanced confidence of half the conditional discrimination predicting a positive outcome (Hypothesis 1). In contrast, the high introvertive anhedonia group have typically displayed no preference for the processing of positive and negative stimuli (experiments 3 & 4). Reduced processing of outcomes should make them less discriminable and it would therefore be predicted that the high introvertive anhedonia group would be generally less successful at acquiring the overall discrimination. They should therefore display reduced confidence of outcomes of all elements of the discrimination regardless of valence (Hypothesis 2).

The second part of the experiment will partially reverse the biconditional discrimination and examine the immediate effects of positive and negative prediction error. It could be predicted that a processing preference to positive stimuli would increase the orienting response or detection of reward when an aversive outcome was expected (i.e. during positive prediction error) (see figure 21 panel 3c). However, it is also possible that a processing preference to positive stimuli might increase the detection of aversive outcomes when a stimulus that predicts an appetitive outcome changes to predict an aversive outcome. A low introvertive anhedonia group, who have consistently displayed a processing preference to positive stimuli, would therefore be more sensitive than the high introvertive anhedonia group to either positive or negative prediction error and display enhanced confidence of the predictive value of stimuli when outcomes valence changes (Hypothesis 3). In contrast, high introvertive anhedonic groups have previously displayed no preference for the processing of positive or negative stimuli (experiments 3 & 4). It could therefore be predicted that a high introvertive anhedonia group would be insensitive to both positive and negative predication error and should not therefore display behavioural changes in confidence when the valence of outcomes change (Hypothesis 4).

The third part of the experiment examined confidence ratings of the predictive strength of the four elements composing the biconditional discrimination after the five post revaluation trials in the high and low introvertive anhedonia group. A partial revaluation of a biconditional discrimination such that AX→allergy but AY→no allergy and BX→allergy but BY→no allergy would mean that elements X and Y would become predictive of the outcome making cue A and B redundant. If the high introvertive
anhedonia group have a greater tendency to process elements and not take account of accompanying stimuli (Haselgrove and Evans, 2010) then after the five revaluation trials they should be more confident than the low introvertive anhedonia group of the predictive strengths of elements X and Y (Hypothesis 5).

4.1.1: Experiment 6. Method

Introduction

This experiment was designed to examine firstly whether processing preferences to stimuli with a positive or negative valence will affect the construction, maintenance and updating of contextual rules that underpin successful performance of biconditional discriminations and secondly whether such processing preferences influence the behavioural adjustment to positive and negative prediction errors signals that support new learning.

It is necessary to highlight, however, that operant conditional discrimination procedures, as used, for example, by Dunn and Killcross (2006), only require that rules relating to an outcome be learned. For example, a correct lever press for reward (i.e. lever right = Y or lever left = X) is disambiguated by (or conditional on) a preceding stimulus (i.e. A or B) such that a stimulus A-Y and B-X predicts food. Successful performance of conditional discriminations requires the acquisition of ‘if A then Y = food’ and ‘if B then X = food’. It is not necessary to learn that ‘if A then X = no food’ and ‘if B then Y = no food’. In essence, the acquisition of conditional discriminations reflects the acquisition of two binary associations (i.e. A→X and B→Y). However, a biconditional discrimination with Pavlovian conditioning procedures requires that outcomes of all combinations of stimuli be learnt. Typical biconditional discrimination might consist of four auditory stimuli (A, B, C and D), two visual stimuli (X and Y) and two outcomes (food and no food) (e.g. Honey and Watt, 1998). The presentation of A or B followed by X predicts food but their presentation followed by stimulus Y predicts no food. Conversely, the presentation of C or D followed by Y predicts food but their presentation followed by stimulus X predicts no food.

The current experiment conducted a simpler bi-conditional discrimination using four stimuli (A, B, X and Y) and two outcomes (positive and negative) (see Table 30 below). After its acquisition, positive and negative prediction errors were generated by reversing
the predictive outcomes of half the discrimination. A negative prediction error was generated by presenting an aversive outcome when an appetitive outcome was expected. Conversely, a positive prediction error was generated by presenting an appetitive outcome when an aversive outcome was expected.

**Participants**

Fifty four participants were recruited into the study 77.8% of who were female. The sample had a mean age of 22.31 years with a standard deviation of 6.57. Recruitment of high and low introvertive anhedonia groups was identical to that in the previous 5 experiments. Recruitment was again based on age and gender norms of the upper and lower quartile scores of a normed introvertive anhedonia distribution (Mason and Claridge, 2006; see Table 5). Exclusion criteria were also identical to experiments 4 and 5. The size and basic demographics of the high and low introvertive anhedonia groups (i.e. gender and age) were also not known until the end of data collection and are therefore reported in the results section.

**Apparatus and Materials**

The bi conditional discrimination task was programmed in visual basic 6 and presented on a PC running Windows XP. The task was a variant of the ‘allergist’ paradigm often used in studies of causal learning in humans. The task was modified in order to incorporate outcomes relating to physical pleasure and physical threat. ‘Orgasm’ and ‘bloody’ were selected as the positive and negative outcomes for three reasons. Firstly, they had equal, though opposing, extreme valence and arousal ANEW ratings (Bradley and Lang, 1999). Secondly, both words had been previously normed as belonging to a category of words that relate to an individual’s ‘physical’ world (see appendix 3). Thirdly, they had been previously used and shown to generate effects in the emotional Stroop, dot probe and affective priming experiments presented earlier in this thesis.

In order to incorporate such outcomes into the bi-conditional discrimination task a cover story was devised based on a fictitious character’s visits to a brothel. The bi-conditional discrimination task exposed participants to causal relations between four different compound events (AX, AY, BX, AY) and a positive or negative outcome. That is, the
meeting of the fictitious character with pairs of sex workers at the brothel leading to either ‘several orgasms’ or a ‘bloody face’. Eight different female names were used for the sex workers in the task (Claire, Edda, Marien, Anika, Sofie, Helena, Laila and Gertrud), four of which were allocated randomly for each participant to the elements of the compound events (A, B, X, Y).

Procedure

Participants were tested individually in an experimental testing booth. Each participant first read a cover story of the scenario behind the biconditional discrimination task, which described a fictitious character’s visits to a brothel (Appendix 5). Each trial presented participants with pairs of female names and participants were required to rate, on a 9-point scale, whether the names predicted a positive or negative outcome for the fictitious character. Participants were instructed to give a rating of 1 if certain that the pairs of female names predicted a positive outcome (i.e. several orgasms), a rating of 9 if certain that the pairs of female names predicted a negative outcome (i.e. a bloody face) and a rating of 5 if uncertain of the outcome. After entering their rating, participants were provided with feedback of the actual outcome of each trial. Each of the four compound trial types (AX, AY, BX, AY) were presented randomly once within each cycle of four trials. Each trial type was presented 15 times in stage 1, and 5 times in the revaluation stage 2 giving a total of 80 trials. During a final test stage individual female names, which made up the elements of the four trial types (A, B, X and Y), were presented randomly once in trials were no feedback was provided (see Table 30 for task design).
The experimenter supervised each participant during the completion of the first two trials to ensure their understanding of the task and to explicitly remind them to use the feedback provided of the actual outcome of each trial to inform their prediction ratings on future trials.

**Method of analyses**

Multiple and logistic regressions were first conducted to account for the possible confounding influence of other schizotypal personality dimensions not of direct relevance to the current investigation on the acquisition of the biconditional discrimination and on revaluations.

The multiple regression analysis included a measure of the effect of outcome valence on the acquisition of the discrimination as the dependent variable. This was calculated for each participant by subtracting the mean confidence ratings of the last training trials with a positively valenced outcome (AY+ trial 15 / BX+ trial 15) from the mean confidence ratings of the last training trials with a negatively valenced outcome (AX- trial 15 / BY- trial 15). A larger value would indicate greater discrimination. The unusual experiences, impulsive non-conformity and cognitive disorganisation schizotypal personality dimensions were entered into the analyses as predictors. Data were screened for outliers, which if present were removed from the analyses. Furthermore, normality of the data was assessed and if significant skew were present then the variable was transformed until normality was achieved.

A similar analysis was conducted for data from the revaluation stage by examining the magnitude of positive and negative prediction error. A measure of positive prediction error learning was calculated by subtracting the confidence rating of the first revalued trial with a positively valenced outcome from the confidence rating of the second revalued trial with a positively valenced outcome (AX+ trial 1 minus AX+ trial 2). A positive value would indicate that positive prediction error learning had occurred. A similar measure was calculated for negative prediction error learning. However, to ensure that a positive value also indicated the presence of prediction error learning then confidence ratings of the second revalued trial with a negatively valenced outcome were subtracted from the confidence ratings of the first revalued trial with a negatively valenced outcome (AY- trial 2 minus AY- trial 1).
The majority of data for these measures of positive and negative prediction error learning were 0 making all other data outliers. The variables were therefore not normally distributed and could not be normalised with transformations. Measures of positive and negative prediction error learning were therefore recoded into nominal variables consisting of two categories. A prediction error learning category consisted of participants with values of the measure of positive and negative prediction error greater than 0 and a no prediction error learning category consisted of participants with values equal to and less than 0. These dichotomised measures of positive and negative prediction error learning were then included as the dependent variable in two separate logistic regression analyses with the schizotypy trait dimensions not of direct relevance to the current investigation as predictor variables.

Data of the extreme high and low introvertive anhedonia groups from the three stages of the experiment were then examined consecutively: biconditional discrimination training, revaluation and test.

Analyses of biconditional discrimination training examined the high and low introvertive anhedonia groups mean prediction ratings of the last four trials to the four stimulus compounds in a 2x (outcome valence: positive vs. negative) by 2x (stimulus compound: AX vs. BY and BX vs. AY) by 2x (introvertive anhedonia group: high vs. low) mixed ANOVA. A main effect of valence but the absence of a valence by compound interaction would indicate that the discrimination had been successfully acquired.

Analyses of the revaluation stage data were conducted using 2, 3-way ANOVA’s. The first focused on the effect of positive prediction error by comparing ratings on positively revalued trials with rating of trials that retained the same negative outcomes from training. There were 3 factors (trial number, revaluation and group) with 2 levels each. A second 3-way ANOVA focused on the effect of negative prediction error by comparing ratings on negatively revalued trials with rating of trials that retained the same positive outcomes from training. There were again 3 factors (trial number, revaluation and group) with 2 levels each.

Analyses at test compared elements of compounds that after revaluation were predictive of outcomes with elements of compounds that were not predictive of outcomes using a 3-way
2x (effect of revaluation: predictive vs. uncertain) by 2x (element: A/Y vs. B/X) by 2x (introvertive anhedonia group: high vs. low) mixed ANOVA.

All post hoc analyses were conducted using t-test with the critical values for significance adjusted for multiple comparisons using the Bonferroni method.

### 4.1.2: Experiment 6. Results

**Demographics**

Mean ages and gender composition of the high and low introvertive anhedonia groups are presented in Table 20. According to the criteria outlined in the method section, 27 participants were defined as low introvertive anhedonia and 27 as high introvertive anhedonia. The high and low introvertive anhedonia groups did not differ in age ($t=0.514$, $df=52$, $p>.05$) and the groups were not associated with gender ($p>.05$ Yates correction) (see table 31).

<table>
<thead>
<tr>
<th></th>
<th>Low (n=27)</th>
<th>High (n=27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Age (mean/SD)</td>
<td>21.9 (6.3)</td>
<td>22.8 (7.0)</td>
</tr>
</tbody>
</table>

The high introvertive anhedonia group had higher mean unusual experiences, cognitive disorganisation and impulsive non-conformity scores than the low group (see table 32). These group differences were not statistically significant for the impulsive non-conformity ($t=0.107$, $df=52$, $p>.05$) subscale scores. However, the high introvertive anhedonia group did have significantly higher unusual experiences ($t=2.302$, $df=52$, $p<.05$), cognitive disorganisation ($t=2.670$, $df=52$, $p<.01$) scores.
Table 32
O-LIFE total scores and subscale scores for the high and low introvertive anhedonia groups

<table>
<thead>
<tr>
<th></th>
<th>Low (n=27)</th>
<th></th>
<th>High (n=27)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>(SD)</td>
<td>Mean</td>
<td>(SD)</td>
</tr>
<tr>
<td>Unusual Experiences</td>
<td>7.96</td>
<td>(5.65)</td>
<td>12.07</td>
<td>(7.36)</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>11.56</td>
<td>(4.70)</td>
<td>15.41</td>
<td>(5.84)</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>8.37</td>
<td>(3.22)</td>
<td>8.26</td>
<td>(4.33)</td>
</tr>
<tr>
<td><strong>Introvertive anhedonia</strong></td>
<td><strong>1.22</strong></td>
<td><strong>(0.80)</strong></td>
<td><strong>11.19</strong></td>
<td><strong>(2.87)</strong></td>
</tr>
<tr>
<td>O-LIFE Total</td>
<td>29.11</td>
<td>(9.67)</td>
<td>46.93</td>
<td>(13.54)</td>
</tr>
</tbody>
</table>

Experimental analyses

**Multiple Regression analyses: Outcome valence effect**

The multiple regression analyses included a measure of the effect of outcome valence on the acquisition of the discrimination as the dependent variable (mean of AY+ trial 15 and BX+ trial 15 minus the mean of AX- trial 15 and BY- trial 15). The unusual experiences, impulsive non-conformity and cognitive disorganisation schizotypy dimensions were entered as predictors. The unusual experiences variable had significant skew and was subjected to a square root transformation. All other variables were normally distributed. The unusual experiences, impulsive non-conformity and cognitive disorganisation variables were subsequently examined in the regression using the enter method. A significant model did not emerge (F(3,50)=0.856, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of the effect of outcome valence on the acquisition of the discrimination (see appendix 1. table A1.16 for coefficients of predictors).

**Logistic regression analyses: Positive prediction error**

A binary logistic regression analysis was conducted with a dichotomised measure of positive prediction error as the dependent variable.
[Positive prediction error = change in confidence rating greater than 0]

vs.

[No positive predication error = [no change in confidence rating or change in confidence rating less than 0].

The analysis included unusual experiences, impulsive nonconformity and cognitive disorganisation schizotypy subscales as predictor variables. A total of 54 cases were analysed but a significant model did not emerge (omnibus chi-square = 1.939, df = 3, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of positive prediction error learning (see appendix 1. table A1.17 for coefficients of predictors).

**Logistic regression analyses: Negative prediction error**

A binary logistic regression analysis was conducted with a dichotomised measure of negative prediction error as the dependent variable.

[Negative prediction error = change in confidence rating greater than 0]

vs.

[No negative predication error = change in confidence rating less 0 or no change in confidence rating]

The analysis included unusual experiences, impulsive nonconformity and cognitive disorganisation schizotypy subscales as predictor variables. A total of 54 cases were analysed but a significant model did not emerge (omnibus chi-square =1.004, df = 3, p>.05) indicating that none of the included schizotypal dimensions were significant predictors of negative prediction error learning (see appendix 1. table A1.18 for coefficients of predictors).

**Stage 1: Biconditional discrimination training**

Figure 22 below presents the mean prediction responses of the high and low introvertive anhedonia groups to compounds that predicated positive (AY+/BX+) and negative (AX-/BY-) outcomes during the biconditional discrimination training in stage 1. The figure
indicates that by trial 15 both the high and low introvertive anhedonia groups were predicting, with some confidence, the correct outcome valence of compounds. At trial 15 all mean responses were above and below a rating of uncertainty, which is represented on the vertical scale of figure 22 as a response of 5.

Mean responses of the high and low introvertive anhedonia groups over the last four training trials to compounds with negative outcomes are somewhat parallel (see upper half of figure 22). However, responses of the high and low introvertive anhedonia groups over the same trial numbers for compounds with positive outcomes diverge. It is uncertain whether such divergence is a chance factor. Therefore prediction ratings of the high and low introvertive anhedonia groups to the last four trials to compounds with positive and negative outcomes were amalgamated (see figure 23).

Figure 22. Mean responses of the high and low introvertive anhedonia groups over the fifteen biconditional discrimination training trials to compounds with positive (AY+/BX+) and negative (AX-/BY-) outcomes.
The mean of the ratings of the last four training trials to all four stimulus compounds (Figure 23) were entered into a 2x (outcome valence: positive vs. negative) by 2x (compound: AY vs. BX & AX vs. BY) by 2x (introvertive anhedonia group: high vs. low) mixed ANOVA. It revealed a main effect of outcome valence (F(1,52)=34.04, p<.001 \( \eta^2=.39 \)) indicating that mean prediction ratings for compounds with positive and negative outcomes significantly differed. Furthermore, there was no outcome valence by compound interaction (F(1,52)=0.065, p>.05) indicating that positive and negative prediction ratings did not differ between the compound that predicted the same outcome. This indicates successful acquisition of the biconditional discrimination. The analyses further revealed no 3-way outcome valence by compound by introvertive anhedonia group interaction (F(1,52)=0.685, p>.05) and no 2-way outcome valence by group interaction (F(1,52)=2.519, p>.05) indicating that the degree to which the biconditional discrimination was acquired did not differ between the high and low introvertive anhedonia groups.

Figure 23. Means of the prediction ratings of the high and low introvertive anhedonia group to the last four training trials for compounds with positive and negative outcomes.
Stage 2: Revaluation

During stage 2, the predicted outcome valence, established in stage 1, of two compounds (i.e. AX and AY) was revaluated to predict the outcome with the opposite valence (see table 30 in method). Figure 24 and 25 on the following page present the mean prediction responses of the high and low introvertive anhedonia groups to the first two revaluation trials for compounds that did not undergo revaluation (BY and BX) and for compounds that did undergo (AX and AY) revaluation.

The strategy behind the analyses was to compare the first revaluation trial with subsequent trial where the behavioural change in prediction rating was expected to occur. Revalued compounds that came to predict different outcome were compared with control compounds that had the same outcome valence at the end of training in stage 1 but did not undergo revaluation in stage 2. Two 3-way analyses of variance, one for the compound revalued with a positive outcome (i.e. AX+) and another for the compound revalued with a negative outcome (AY-), compared trial number (first vs. second) by revaluation compound (revalued vs. not revalued) by introvertive anhedonia group (high vs. low).

The first ANOVA compared mean responses of the first two revaluation stage trials for compound AX+, which was revalued to predict a positive outcome, with the mean responses of the first two revaluation stage trials for compound BY-, which was not revalued (see figure 24a and 25a above). The ANOVA revealed no trial number by revalued compound interaction (F(1,52)=0.425, p>.05) indicating that the changes in prediction ratings from the first to the second trial did not differ for compound AX, that underwent revaluation, or compound BY, that did not undergo revaluation. The analysis further revealed no 3-way trial number by revalued compound by introvertive anhedonia group interaction (F(1,52)=0.169, p>.05) indicating the high and low introvertive anhedonia groups were not differentially sensitive to changes in the mean prediction response of compound AX (see figure 24a and 25a).
**Figure 24a and 24b.** Mean prediction responses of the high and low introvertive anhedonia group to compounds that did not undergo revaluation in stage 2. Figure 24a (left) displays the mean responses of the first and second revaluation trials to compound BY which was conditioned with a negative outcome during stage 1 discrimination training and continued to predict a negative outcome during revaluation in stage 2. Figure 24b (right) displays the mean responses of the first and second revaluation trials to compound BX, which was conditioned with a positive outcome during stage 1 discrimination training and continued to predict a positive outcome during revaluation in stage 2.

**Figure 25a and 25b.** Mean prediction responses of the high and low introvertive anhedonia groups to compounds that underwent revaluation in stage 2. Figure 25a (left) displays the mean responses of the first and second revaluation trials to compound AX, which was conditioned with a negative outcome during stage 1 discrimination training and revalued during stage 2 to predict a positive outcome. Figure 25b (right) displays the mean responses of the first and second revaluation trials to compound AY, which was conditioned with a positive outcome during stage 1 discrimination training and revalued during stage 2 to predict a negative outcome.
The second ANOVA compared mean responses of the first two revaluation stage trials for compound AY-, which was revalued to predict a negative outcome, with the mean responses of the first two revaluation stage trials for compound BX+, which was not revalued (see figure 24b and 25b above). The ANOVA revealed no trial number by revalued compound interaction (F(1,52)=1.908, p>.05) again indicating that the changes in prediction ratings from the first to the second trial did not differ for compound AY that underwent revaluation and compound BX that did not undergo revaluation. The analysis did however reveal a significant 3-way trial number by revalued compound by introvertive anhedonia group interaction (F(1,52)=10.287, p=.002, η²=.16) indicating that the high and low introvertive anhedonia groups differed in their prediction rating changes from trial 1 to trial 2 for the revalued (i.e. AY) and non revalued (i.e. BX) compounds (see figure 24b and 25b above).

Post hoc analyses used repeated measures t-tests with alpha adjusted for 4 comparisons and the critical value for significance set at .01. The analyses confirmed that prediction ratings of the outcome of compound BX+ (see figure 24b) at trial 1 did not differ to those at trial 2 for either the high (t=0.377, df=26, p>.01) or low (t=1.174, df=26, p>.01) introvertive anhedonia groups. However, the same analyses conducted for compound AY (see figure 25b) found that the low introvertive anhedonia group had significantly higher prediction ratings at trial 2 than trial 1 (t=3.701, df=26, p=.001). In contrast, the prediction rating of the high introvertive anhedonia group did not significantly differ at trial 2 than at trial 1 (t=1.322, df=26, p>.01).

**Stage 3: Test**

After biconditional discrimination training (stage 1) the predictive values of the compound elements should be uncertain (i.e. at or near 5 on the response scale). However, during revaluation (stage 2), the biconditional discrimination was altered to a simpler conditional discrimination whereby element Y predicted a negative outcome and element X predicted a positive outcome. The predicted value of elements A and B was conditional on whether they were presented with either element Y or X thus making their individual predicative values uncertain. To test the success of revaluation the elements of the compounds that constituted the biconditional discrimination were presented in the test stage once. As expected, both the high and low introvertive anhedonia groups prediction ratings of Y was above the line of uncertainty thus indicating a negative outcome, and their prediction
ratings of element X were below the line of uncertainty, indicating a positive outcome (see figure 26). Furthermore, as expected both the high and low introvertive anhedonia groups were uncertain about the predicative value of element A. However, the high introvertive anhedonia group mean response to element B was above the line of uncertainty, indicating their prediction that element B has a negative outcome. In contrast, the low introvertive anhedonia group responded below the line of uncertainty indicating their prediction that element B has a positive outcome.

![Figure 26. The high and low introvertive anhedonia groups mean prediction ratings at stage 3 to the elements of the compounds that were presented during biconditional discrimination training (stage 1) and revaluation (stage 2). If revaluation was successful then Y should predict a negative outcome, X should predict a positive outcome while the predictive outcome of elements A and B should be uncertain.](image)

The means presented in Figure 23 were analysed in a 3-way 2x (effect of revaluation: predictive vs. uncertain) by 2x (element: A vs. B and Y vs. X) by 2x (introvertive anhedonia group: high vs. low) mixed ANOVA. It revealed a 2-way revaluation by element interaction (F(1,52)=4.764, p<.05, \(\eta^2=.08\)) suggesting that revaluation had an effect on elements that predicted an outcome (i.e. X and Y) but not on elements that did not predict an outcome (i.e. A and B). Post hoc analyses using two repeated measures t-tests, with the critical value adjusted for 2 comparisons and set at .025, confirmed that while the prediction ratings for elements X and Y were significantly different (t=3.042,
df=53, p<.025, Cohen’s d=0.67] prediction ratings for A and B were not (t=0.033, df=53, p>.025).

The ANOVA analyses did not reveal a 3-way revaluation by element by introvertive anhedonia group interaction (F(1,52)=1.946, p>.05) indicating that the effects of revaluation on the elements did not differ between the high and low introvertive anhedonia groups. Post hoc analyses using repeated measures t-tests with the critical value adjusted for 4 comparisons and set at .01, confirmed the results of the ANOVA. Prediction ratings did not significantly differ between elements A and B for either the high (t=0.992, df=26. p>.01) or low (t=0.925, df=26. p>.01) introvertive anhedonia groups. Prediction ratings also did not significantly differ between elements X and Y for either the high (t=1.846, df=26. p>.01) or low (t=2.398, df=26. p>.01) introvertive anhedonia groups.

4.1.3: Experiment 6. Discussion

Summary

Analyses of the data from stage 1 indicate that both the high and low introvertive anhedonia groups acquired the biconditional discrimination to the same degree. The data from stage 2 indicate that the low introvertive anhedonia group was immediately sensitive to negative prediction error when compound AY was reevaluated from predicting a positive outcome to a negative outcome. In contrast, the high introvertive anhedonia group showed no such sensitivity. Furthermore, neither the high nor low introvertive anhedonia group were immediately sensitive to the revaluation of compound AX as it changed from predicting a negative outcome to a positive outcome. The data from stage 3 further indicate that the high and low introvertive anhedonia group were not differentially sensitive to the processing of the elements that constituted the compounds of the discrimination.

Comment on findings

The current experiment aimed to address three research questions in three distinct experimental stages. 1. Does outcome valence differentially influence executive cognitive processes involved in the acquisition of a conditional discrimination in high and low
introvertive anhedonia? 2. Are high and low introvertive anhedonic groups differentially sensitive to positive and negative prediction errors? 3. Do high scoring introvertive anhedonic participants have a greater tendency to process elements?

**Stage 1: Biconditional discrimination training**

The statistical analyses of stage 1 indicate that both the high and low introvertive anhedonia groups acquired the biconditional discrimination to the same degree. The findings were inconsistent with hypothesis 1 which predicted that the processing preferences of the low introvertive anhedonia group to positively valenced stimuli, previously seen in experiment 3, 4 and 5, would differentially influence the rate at which the discrimination was acquired. This processing preference was expected to increase the salience of appetitive outcomes thereby facilitating the acquisition of half the discrimination with positively valenced outcomes. The findings were also inconsistent with hypothesis 2 which predicted that blunted processing of valenced stimuli of the high introvertive anhedonia group, previously seen in experiments 3 and 4, would reduce the rate at which the discrimination was acquired. Reduced processing of valenced outcomes was expected to decrease the salience of both appetitive and aversive outcomes thereby decreasing the rate that the discrimination was acquired.

These results suggest that the emotion cue processing preferences of the high and low scoring introvertive anhedonic groups do not differentially influence executive functions involved in the acquisition of biconditional discriminations. The results from stage 1 therefore suggest that valenced outcomes did not differentially support the construction, maintenance and updating of the contextual rules that guide behaviour in the high and low introvertive anhedonia groups.

The random presentation of cues was argued to reduce the likelihood of the use of task setters in the solution of the biconditional discrimination. However, it is still possible that task setters influenced the acquisition of the biconditional discrimination. In Haddon et al.’s (in press) study the acquisition of the discrimination proceeded hierarchically where two specific cues (A and B) represented by meat products acted as task setters with other elements of the discrimination (X and Y) being represented by fruit and vegetable products. Cues in the current study were all of the same type (i.e. women’s names) and were presented randomly in two locations in efforts to prevent any one cue being used as a
task setter. However, one cue may still have been used as a task setter based not on location but on its relative salience or some other arbitrary feature selected by the participant. Eight women’s names were used in the study (i.e. Claire, Edda, Marien, Anika, Sofia, Helena, Laila and Gertrud) and four were assigned randomly to each participant as cues. However, some names or feature of them may have been perceived as more salient than other names for any number of reasons. For example, the name ‘Gertrude’ might be used less frequently as a Christian name in Britain than the name ‘Claire’. Being unusual might make it more salient and increase its likelihood of being used as a task setter. In this example, when Gertrude is presented with Anika then there might be a good outcome but when Gertrude is presented with Claire then there will be a bad outcome. Learning can still proceed hierarchically but the delayed emergence of task setters might make the discrimination harder to acquire and reduce its sensitivity to a context processing deficit in high scoring introvertive anhedonics. This might be tested by a future experiment whereby biconditional discrimination performance is compared with cues presented in a consistent locations and cues presented randomly.

Stage 2: Revaluation

The analyses of the revaluation stage indicate that the high and low introvertive anhedonia groups have fundamental differences in processes involved in prediction error learning. The low introvertive anhedonia group were immediately sensitive to negative prediction error, that is, when appetitive outcomes become bad, while the high introvertive anhedonia group were immediately insensitive to positive or negative prediction error.

These findings were consistent with hypothesis 3, which predicted that a processing preference for positively valenced stimuli in the low introvertive anhedonia group would increase sensitivity to either positive or negative prediction error. It might be expected that a processing preference to positive stimuli would increase the orienting response or detection of reward when an aversive outcome was expected. However, the low introvertive anhedonia group was relatively insensitive to positive prediction error. They may have not detected the AX→punishment to AX→reward outcome valence change on the first revaluation trial and/or may not have updated their prediction ratings on the second revaluation trial. It is also possible that a processing preference to positive stimuli might increase the detection of aversive outcomes when a stimuli that predicts an appetitive outcome changes to predict an aversive outcome. The data supported this
possibility and indicated that the low introvertive anhedonia group was immediately sensitive to the disruption in reward prediction signals that characterises a negative prediction error. The low introvertive anhedonia group detected the AY→reward to AY→punishment outcome valence change on the first revaluation trial then immediately updated their prediction of the new outcome on the second revaluation trial.

Findings from the revaluation stage were also consistent with hypothesis 4, which predicted that the absence of an emotion cue processing preference in the high introvertive anhedonia group would reduce their sensitivity to changes in outcome valence during both positive and negative prediction error. The disruptions of signals that predict an aversive or appetitive outcome may, or may not, have been detected by the high introvertive anhedonia group. Regardless, such disruption did not generate new learning immediately. The high introvertive anhedonia group was immediately insensitive to both positive and negative prediction error. They may not have detected the AX→punishment to AX→reward or the AY→reward to AY→punishment outcome valence change on the first revaluation trial and/or may not have updated their prediction ratings of the new outcomes on the second revaluation trial.

Successful acquisition of the biconditional discrimination suggests that both the high and low introvertive anhedonia group had formed the AY→reward and AX→punishment associations to the same degree. The presentation of compound AY must therefore have excited midbrain dopamine neuron activity and the presentation of AX inhibited midbrain dopamine neuron activity (see figure 21 panel 1a). These activations can also be presented within the framework of the SOP model (Wagner, 1981). The presentation of AY would have generated an A2 activation state in the nodes of the appetitive outcome and the presentation of AX generated an A2 activation state in the nodes of the aversive outcome.

The low introvertive anhedonia group were immediately sensitive to negative prediction error. In line with previous discussion of dopamine coding of stimulus outcomes, the revaluation of AY→reward to AY→punishment can be interpreted as resulting in excitation of dopamine neurons at the presentation of compound AY but inhibition of the same neurons at the presentation of an aversive outcome when a reward was expected (see figure 21 panel 1c). Within the framework of the MSOP (Dickinson and Burke, 1999) model, which can account for positive and negative prediction error, once the AY→reward association had formed, then the elements of nodes of both compound AY and nodes of the appetitive outcome would be in the A2 activation state. According the MSOP model,
when elements of cue and outcome nodes are both in the A1 or A2 activation states then excitation of associations occurs. However, when the elements of cue and outcome nodes are in opposing states of activation (i.e. A1→A2 or A2→A1) then inhibition of the association occurs. The presentation of AY→punishment, during the first revaluation trial, when AY→reward was expected, would mean that elements of the node of compound AY would be in the A2 state while the unexpected presentation of an aversive outcome would excite elements of the aversive outcome node from the inactive state to the A1 state. This would inhibit the AY→reward association and elements of the nodes of the appetitive outcome would return from the A2 state to an inactive state. The low introvertive anhedonia group was immediately sensitive to the revaluation on trial 1, when AY→reward changed to AY→punishment, as they behaviourally adjusted their predictions of the new outcome on the second revaluation trial. Therefore, during the second revaluation trial, elements of the node of compound AY would be in the A2 state and already drive a significant number of elements of the aversive outcome node into the A2 state.

The lack of sensitivity of the high introvertive anhedonia group to negative prediction error might therefore have resulted from three possible causes: 1) a failure in generating the learning signal that consists of the inhibition of dopamine neurons to an aversive outcome when an appetitive outcome was expected (see figure 21 panel 1c), or, in term of the MSOP model, a failure of elements of the node of compound AY to activate the A1 state of elements of the aversive outcome node, 2) a failure in detecting the error learning signal by an error detection mechanism (see Holroyed & Coles 2002), or, in terms of MSOP, a failure of the opposing states of activation of the elements of the AY node and elements of the aversive outcome node to trigger the inhibition of the AY→reward association or 3) a failure of such a signal to update representations in the PFC, or, in the term of MSOP, a failure of an AY→punishment association to form.

The updating of representations triggered by negative prediction error might involve the modification of conditional rules by inhibiting the representation of the predicted aversive outcome, which would then enable the formation of a new association based on an appetitive outcome. It has been suggested that dopaminergic signals from the VTA might control the ‘gating’ of afferent information into the prefrontal cortex (O’Rielly, Braver & Cohen, 1999). These dopamine signals might be detected by a mismatch or error detection mechanism (see Holroyed & Coles 2002), which subsequently signals the ‘gate’ allowing afferent information into the prefrontal cortex. This would subsequently allow the
updating of conditional rules by inhibiting the representation of the predicted appetitive outcome and enabling the formation of a new association.

The lack of sensitivity of the low and high introvertive anhedonia group to positive prediction error, that is, the revaluation of $AX \rightarrow$ punishment to $AX \rightarrow$ reward, may have resulted from failures in processes at any or all three of these stages. Behavioural insensitivity to positive prediction error might result from a failure to generate the learning signal, a failure in detecting the learning signal or a failure in the updating of conditional rules.

**Stage 3: Test**

The analyses of stage 3 data of the current experiment suggest high and low introvertive anhedonia group were not differentially sensitive to the processing of the elements that constituted the compounds of the discrimination. This is inconsistent with hypotheses 5, which predicted that if the high introvertive anhedonia group have a greater tendency to process elements and not take account of accompanying stimuli (Haselgrove and Evans, 2010) then after the five revaluation trials they should be more confident than the low introvertive anhedonia group of the predicative strengths of elements X and Y.

The sample as a whole rated X and Y as predictive of outcomes and were uncertain of the predictive values of A and B. These results were expected from changing the original conditional discrimination to a simple discrimination. However, when tested separately neither the high nor low group generated any significant differences between X and Y. This indicates that the global effect of reevaluating a conditional to a simple discrimination was driven by participants from both the high and low introvertive anhedonia group. The absence of effects in both the high and low introvertive anhedonia groups further suggests that the current experimental parameters do not seem to provide a particularly sensitive measure of the processing of elements. This may have subsequently prevented the detection of between group differences. Definitive conclusions about the differential ability of high and low scoring introvertive anhedonics to process elements can therefore not be made from results of the current experiment.
Synthesis

The experiment explored the differential influence of outcome valence on learning biconditional discriminations and immediate learning resulting from positive and negative prediction error in high and low introvertive anhedonia groups. Between groups effects were isolated to difference in prediction error learning. The following discussion will consider two possible accounts for these differences and present them within the framework of a three-layer connectionist network that represents both appetitive and aversive outcomes and incorporates principles of Wagner’s (1981) SOP model. The network is based on that of Honey and Ward-Robinson (2002) but is modified to include inhibitory links between appetitive and aversive outcomes to account for evidence indicting the likely mutual inhibition of pain and pleasure neurobiological systems (see Leknes & Tracy, 2008 for discussion).

According to Rescorla (2000), changes in association strength that stimuli undergo during revaluation occur as a negatively accelerated function. Therefore, the stronger the association then the greater is the change in association strength when the predicted outcome of a stimulus is revaluated. Participants’ prediction ratings are only an approximation of the weights of associations. It is therefore possible that the low introvertive anhedonia group had formed stronger associations than the high introvertive anhedonia group, during biconditional discrimination training, for compounds with appetitive outcomes. The low introvertive anhedonia groups mean prediction rating for compounds with appetitive outcomes were descriptively more confident than the prediction rating of the high introvertive anhedonia group to the same compounds (see Figure 20). Stronger associations at the end of training should theoretically result in a larger prediction error signal during revaluation. This would therefore account for the low introvertive anhedonia group’s immediate sensitivity to the negative prediction error generated by reevaluating $AY\rightarrow$reward to $AY\rightarrow$punishment. Such an interpretation would also account for why neither the high nor low introvertive anhedonia group were immediately sensitive to positive prediction error. Although at the end of biconditional discrimination training the low introvertive anhedonia group were descriptively more confident than the high introvertive anhedonia group in their predictions of the outcome of compound $BY$-, the two groups were comparably less confident in their predictions of the outcome of compound $AX$- (see Figure 20). Weak associations at the end of training would result in small prediction error signalling during revaluation thus accounting for the lack of immediate sensitivity of the high or low introvertive anhedonia group to the positive
prediction error generated by reevaluating AX→punishment to AX→reward. However, despite such a possibility being theoretically likely the supporting evidence in the current experiment is not conclusive and an additional study would be required to definitively test such an account.

If it is assumed that the high and low introvertive anhedonia group acquired the biconditional discrimination to the same degree, then the sensitivity of the low introvertive anhedonia group to negative prediction error must be due to enhanced signal detection and processing. The negative prediction error signal emanating from the midbrain might be detected by a mismatch or error detection mechanism, perhaps represented in the ACC (e.g. Holroyed & Coles 2002), which subsequently signals the ‘gate’ allowing the prefrontal cortex to update representations. Updating due to negative prediction error (when AY→reward is revaluated to AY→punishment) in the current experiment might involve the inhibition of the appetitive outcome and the strengthening of aversive outcome representations. Recent studies suggest that the orbitofrontal cortex (OFC) might be the locus of the representations of reward value, expected reward and the subjective pleasantness of reinforcers (see Kringlebach, 2005 for review). Lesions to the OFC impair negative prediction error learning, or reversal learning, in humans resulting in specific failures to adjust behaviour following a large loss of reward (Hornak, et al., 2004). A deficit in the representation of reward might impair the detection of its absence during negative prediction error learning. The insensitivity of the high introvertive anhedonia group to the negative prediction error might therefore be due to either failure of prediction error signal detection, a failure of such a signal to update representations or deficits in representing reward value.

Honey and Ward-Robinson (2002) three-layer connectionist network accounts for the nature of the associative structure of biconditional discriminations (see figure 27) and provides a parsimonious interpretative framework on which possible deficits in the high and low introvertive anhedonia groups that may account for the results of the current experiment can be mapped. The network incorporates principles of Wagner’s (1981) SOP model and represents both appetitive and aversive outcomes. The network consists of a layer of input units that feed into a second layer of hidden units which in turn are connected by reciprocal links to a third layer of appetitive and aversive output units. Inhibitory links between aversive and appetitive outcomes have been added to the network to account for evidence indicating that pleasure and pain systems are mutually inhibitory (see Leknes & Tracey, 2008 for discussion).
Figure 24a and 24b presents the connectionist architecture at the end of the biconditional discrimination training for the high and low introvertive anhedonia groups. Possible weaknesses in the network that may account for the current results are represented by a dashed line. The following discussions will outline how such weaknesses in the model may account for the two interpretations of the current results detailed above, that is, whether differences between the high and low introvertive anhedonia groups in their sensitivity to prediction errors result from differences in the strength of associations formed during biconditional discrimination training or in group differences in the ability to update context representations.

Figure 27a and 27b. Connectionist architectures of the discrimination task (based on Honey and Ward-Robinson, 2002) at the end of training for the high and low introvertive anhedonia groups. During revaluation, the predicted outcome valence of hidden units P & Q changed to predict the opposite valence. Possible weaknesses in the networks that may account for the results of the current experiment are represented by a dashed lines (i.e. ----).

Weakness in the prediction error signals feeding back from outcomes might account for the formation of weak associations during biconditional discrimination training. This could subsequently resulted in weak prediction error signalling during revaluation. The formation of these initial associations might have resulted from the processing preference of high and low introvertive anhedonia groups to stimuli of differing valence. For the low introvertive anhedonia group, a consistent processing preference to positive stimuli has
been observed in three different experiments presented earlier in this thesis (experiment 3, 4 & 5). Such a preference might support the formation of strong associations between compounds and appetitive outcomes. This is represented in the connectionist model as intact feed forward and feedback links between hidden units (Q and R) and the appetitive outcome (+) (see Figure 27b). The absence of a preference to the processing of negative stimuli might reduce the negative outcomes ability to support the formation of associations between compounds and aversive outcomes. Such a weakness is represented in the connectionist model as a disruption in the feedback returning from aversive outcomes (-) to hidden units in the second layer (P and S) (see Figure 27b). For the high introvertive anhedonia group the absence of differential processing of positive and negatively valence stimuli has been most consistently observed in earlier experiments of this thesis. The inability to easily differentiate positive and negative stimuli might reduce the ability of both an appetitive and aversive outcomes to support the formation of associations. This is represented in the connectionist model as a disruption in the feedback links from the appetitive outcome (+) to hidden layer units (Q and R) and a disruption in the feedback links from the aversive outcome (-) to hidden layer units (P and S) (see Figure 27a).

If it is presumed, as outlined earlier, that the biconditional discrimination training resulted in the high and low introvertive anhedonia groups forming associations of comparable strength, then differences in sensitivity to revaluation might be due to difference in the ability to update representations. The low introvertive anhedonia group, who were immediately sensitive to negative prediction error when AY→reward was revaluated to AY→punishment, successfully inhibited the appetitive outcome. This is represented in the connectionist model as an intact inhibitory link from the aversive (-) to the appetitive (+) output units (see Figure 24b). In contrast, the lack of immediate sensitivity of the low group to positive predictions error, when AX→punishment changed to AX→reward, might be due to the unsuccessful inhibition of appetitive outcomes. This is represented in the connectionist model as a weakening in the inhibitory links from an appetitive (+) to an aversive (-) output unit (see Figure 27b). The high introvertive anhedonia group, who were insensitive to either positive or negative prediction errors, may have failed to successfully inhibit representations of both aversive and appetitive outcomes. This is represented in the connectionist model as a weakening in the inhibitory links between aversive (-) and appetitive (+) output units (see Figure 27a).
Methodological Problems and Limitations of the Current study

The most prominent methodological confound of the current study was that the high and low introvertive anhedonia groups were not only significantly different on levels of introvertive anhedonia but also on levels of unusual experiences and cognitive disorganisation, the O-LIFE’s positive and disorganised schizotypy dimension. Observed effects cannot therefore be attributed solely to levels of introvertive anhedonia or negative schizotypy. However, multiple regression analyses found that the effect of outcome valence on the acquisition of the biconditional discrimination was unrelated to the unusual experiences, cognitive disorganisation and impulsive non-conformity schizotypy dimensions and global schizotypy scores. A similar analysis using logistic regression indicated that negative and positive prediction error learning was also unrelated to the unusual experiences, cognitive disorganisation and impulsive non-conformity schizotypy dimensions and global schizotypy scores.

Conclusion

The current experiment aimed to address three research questions in three distinct experimental stages. 1. Does outcome valence differentially influence executive cognitive processes involved in the acquisition of a biconditional discrimination in high and low introvertive anhedonia? 2. Are high and low introvertive anhedonic groups differentially sensitive to positive and negative prediction errors? 3. Do high scoring introvertive anhedonic participants have a greater tendency to processes elements?

Analysis of data from the training in stage 1 suggests that both the high and low introvertive anhedonia groups acquired the biconditional discrimination to the same degree. This indicates that outcome valence did not differentially influence the executive processing mechanisms that underpin the acquisition of conditional discriminations in the high and low introvertive anhedonia group. Appetitive and aversive outcomes supported, to the same degree in the high and low introvertive anhedonia groups, the construction, maintenance and updating of the contextual rules that guide behaviour.

Stage 2 data indicate that while both the high and low introvertive anhedonia groups were immediately insensitive to positive prediction error (when bad outcomes become good).
only the low introvertive anhedonia group was immediately sensitive to negative prediction error (when good outcomes become bad).

One interpretation of the absence of immediate sensitivity of the high introvertive anhedonia group to positive and negative prediction errors, generated during revaluation in stage 2, is due to the weak associations formed during biconditional discrimination training in stage 1. This would implicate a global but subtle context processing deficit in the high introvertive anhedonia group. Similarly, the low introvertive anhedonia group might have formed selectively weak associations for compounds with aversive outcomes during stage 1 training thereby resulting in weak positive prediction error signalling during revaluation in stage 2 revaluations. Strong associations for compounds with appetitive outcomes might have resulted in a large negative prediction error during revaluation thereby resulting in immediate behavioural adjustment. However, there was no statistical support for this proposition as the analyses of the high and low introvertive anhedonia group’s prediction ratings indicated that they had acquired the discrimination to the same degree. Alternatively, the rapid learning of the low introvertive anhedonia group to negative prediction error might reflect a selective sensitivity of inhibitory prediction error signals that ‘gate’ the updating of prefrontal cortex representations. The absence of such rapid learning in high introvertive anhedonia group could therefore reflect a general deficit of positive or negative prediction error signals to gate afferent information and update goal representations in the prefrontal cortex. A further possibility is that the high introvertive anhedonia group have orbitofrontal cortex deficits in representing reward value. A deficit in the representation of reward would impair the detection of its absence during negative prediction error learning.

The analyses of stage 3 data indicate that the high and low introvertive anhedonia group were not differentially sensitive to the processing of the elements. However, it is possible that the parameters of the experiment were not sufficiently sensitive to detect between groups differences in the processing of elements.

In sum, outcome valence did not differentially influence the executive functions involved in the acquisition of conditional discriminations. However, the low introvertive group were immediately sensitive to good outcomes becoming bad while the high introvertive anhedonia group were immediately insensitive to a change in outcome valence.
Chapter 5:

General Discussion
5.1: Thesis Summary

The ultimate aim of this thesis was to develop a greater understanding of the cognitive processes specifically associated with negative schizotypy. It aimed to accomplish this by addressing three specific research objectives: 1) explore the possibly of a generalised executive deficit in introvertive anhedonia, 2) explore the possibility of an emotion cue processing deficit in the introvertive anhedonia, and 3) explore possibility of interactions between executive functioning and emotion cue processing in introvertive anhedonia. The performance of groups that scored within the upper (high schizotypy) and lower (low schizotypy) quartile of a normed introvertive anhedonia dimension (i.e. negative schizotypy measure of the O-LIFE (Mason and Claridge, 2006) was examined in six empirical experiments that used measures of executive functioning and emotion cue processing.

Experiment 1 and 2 addressed objective 1 and explored the possibly of a generalised executive deficit in negative schizotypy. The results suggested that negative schizotypy is associated with an executive functioning abnormality that can, according to the definitions of Cohen and Servan-Schreiber (1992), be characterised as decreased efficiency in enhancing contextual representations when an increased demand for cognitive control is detected. There was also some indication that while context processing was disrupted in negative schizotypy, processes dedicated to inhibition were intact.

Experiment 1 presented a larger proportion of colour word Stroop stimuli than neutral Stroop stimuli (i.e. XXXX), which was expected to influence the global reallocation of cognitive resources so that colour naming was strengthened and word reading weakened. Essentially, both context processing representation (i.e. respond to colour rather than word) and inhibitory processing representations (i.e. don’t respond to word) were strengthened. These manipulations of trial proportion were therefore expected to interact with a context processing or inhibitory deficit in different ways. A context processing deficit was expected to result in a smaller Stroop interference effect driven by slower reaction times to neutral stimuli while an inhibitory deficit was expected to result in a larger Stroop interference effect driven by slower responses to incongruent stimuli.

The high introvertive anhedonia group produced a smaller Stroop interference effect than the low group. The low introvertive anhedonia group therefore benefited from the manipulations of trial proportion that enabled the strengthening of context processing
representations (i.e. respond to colour not word) and the production of a large Stroop interference effect. A context processing deficit in the high introvertive anhedonia group meant that they were unable to strengthen contextual representations that would normally result in a large Stroop interference effect. However, predictions were only partly supported. Group differences in the magnitude of the Stroop interference effect were not driven by predicted differences in response speed to neutral stimuli.

The trial proportions of experiment 1 may have resulted in a reallocation of colour naming and word reading resources at a global or macro level. Stroop experiment 2 examined micro level, or trial-by-trial, adjustments in the reallocation of resources to colour naming and word reading with the aim of finding supporting evidence for a context processing deficit in high introvertive anhedonia. Experiment 2 biased processing to word reading by presenting a block of congruent Stroop trials. It then generated a high degree of conflict by presenting an unexpected incongruent Stroop item. Responses to this item minus responses to the previous congruent item provided a measure of Stroop interference. Smaller Stroop interface in this instance was expected to result from efficient inhibitory processes. The high-conflict trial was also thought to signal the requirement for increased cognitive control, which consequently strengthened context representations (i.e. response to colour not word). It was then expected that an increase in cognitive control, and therefore of colour naming processing, would occur on a subsequently presented incongruent trial and significantly increasing response speeds and accuracy to that trial.

The low introvertive anhedonia group demonstrated this ‘adjustment to conflict’ effect. However, as predicted from a context processing deficit, the high introvertive anhedonia group did not adjust their response to the post high conflict trial. The high introvertive anhedonia group were unable to enhance context processing representations (i.e. respond to colour not word) when responding to the second incongruent trial. Furthermore, the high and low introvertive anhedonia group produced comparable sized Stroop interference effects, which indicated comparable functioning of inhibitory processes.

The results suggest that the high introvertive anhedonia group have a context processing deficit but not an inhibitory processing deficit. However, the precise nature of the processes underpinning an inability of the high introvertive anhedonia group to adjust behaviour to conflict is unclear. The specific deficit contributing to the absence of behavioural adaptation to conflict in the high introvertive anhedonia group could be a reduction in conflict detection signals, a reduction in the ability to implement conflict
detection signals to enhance context representations or a reduction in the ability to use or implement context representations to enhance goal directed behaviours. The examination of these components requires further study in future investigations.

In sum, previous studies indicate that executive dysfunction is associated with negative schizotypal traits (Dinn et al., 2002) and also with the negative symptoms of schizophrenia (Ventura et al., 2009; Dibben, et al., 2009). Results from experiment 1 and 2 provide additional evidence that executive dysfunction is present in sub-clinical groups that have atypically many introvertive anhedonic traits. This suggests that executive dysfunction is likely to be a cognitive endophenotype of the negative trait/symptoms of schizotypy/schizophrenia as they are present and can be detected across degrees of clinical compensation.

Objective 2 was addressed by experiments 3 and 4. These explored the possibility of an emotion cue processing deficit in introvertive anhedonia. The performance of the low introvertive anhedonia group in experiments 3 and 4 indicated differences in the processing of positive and negatively valenced stimuli, suggesting that positively valenced stimuli were preferentially processed. The results of experiment 4 further implied that this positive emotion cue processing preference could be characterised by attentional dwell or a difficulty in disengaging attention from the processing of positive cue stimuli. In contrast, the performance of the high introvertive anhedonia group showing no differences in the processing of positive and negatively valenced cues and therefore no preference to the processing of valenced emotional cues.

The results of experiment 3 and 4 therefore suggested that negative schizotypy is associated with an emotion cue processing deficit that can be characterised as the inability of positive or negative emotion cues to attract cognitive resources away from the primary demands of the experimental task. However, neither experiment 3 nor 4 provided any new information regarding the cognitive processes that underpinned the insensitivity of the high introvertive anhedonia group to differentially process valenced emotional cues. The absence of an emotion cue processing difference in the high introvertive anhedonia group might be characterised by the inability to process cues affectively, or by the avoidance of emotional cue processing by some type of a repressor strategy or process. Experiment 5 sought to address these questions, using an affective priming paradigm, by examining whether emotion cues were processed affectively. If affective priming congruency effects were observed then this would indicate that prime and target were processed affectively.
Experiment 5 found affective priming effects in both the high and low introvertive anhedonia groups indicating that both groups processed emotional cues affectively. This further suggested that the high introvertive anhedonia group must have actively inhibited or repressed automatic affective processing mechanisms to avoid processing emotional cues in experiment 3 and 4. Under the conditions of the emotional Stroop and dot probe tasks individuals with many introvertive anhedonic traits might make subjective judgments of incoming emotionally valenced stimuli by assessing context and prior learning. Emotional stimuli might then be judged as low in valence and preattentive automatic emotion evaluation systems might be consequently overridden. This could result in the elimination of emotional Stroop valence effects and dot probe effects.

More detailed analyses of data from experiment 5 found affective priming in the low introvertive anhedonia group with prime-target pairs with negative targets but not prime-target pairs with positive targets. This indicated that the processing of positive primes interfered with the processing of negative targets but that the processing of negative primes did not interfere with the processing of positive targets. These results suggest that that the low introvertive anhedonia group preferentially processed positive cue stimuli and is consistent with the processing of positive and negative emotion cue stimuli in experiment 3 and 4. The high introvertive anhedonia group produced the opposite pattern of effects. Affective priming was observed with prime-target pairs with positive targets but not prime-target pairs with negative targets. This indicated that the processing of negative primes interfered with the processing of positive targets but that the processing of positive primes did not interfere with the processing of negative targets. These results suggest that that the low introvertive anhedonia group preferentially processed negative cue stimuli. These results are inconsistent with the absence of a positive and negative emotion cue processing differences in experiment 3 and 4.

A negative cue processing preference in the high introvertive anhedonia group might have been undetectable in experiment 3 and 4 with the parameters of the emotional Stroop and dot probe tasks. For example, effects with emotional Stroop stimuli are list based and involve a slow mechanism that operates between stimuli. The long interval between stimuli (i.e. 2000ms) in the emotional Stroop task might have provided sufficient time for the high introvertive anhedonia group to override automatic emotional cue processing while the short interval (i.e. 150ms) separating prime and target in the affective priming paradigm might have prevented such suppression.
These results question the appropriateness of the analogy between affective priming effects and emotional Stroop carry over effect. The time separating prime and target (i.e. 150ms) in affective priming and the time separating items in the emotional Stroop task (i.e. 2000ms) might be a critical variable. The short time separating prime and target in the affective priming paradigm means that prima and target are likely to be processed holistically as one stimulus and would be more appropriately interpreted within a classic Stroop response facilitation/competition framework. Resource allocation adjustments to the processing of prime and target are likely to occur within a trial. However, carry over effects in the emotional Stroop task indicate that resource allocation adjustments from the processing the semantic content of the emotional word to colour naming occur trial-by-trial in a similar way to the ‘conflict adjustments effects’ observed in experiment 2. Further experimentation would be required to examine these effects in more detail.

In sum, result from experiments 3, 4 and 5 indicate that an emotion cue processing abnormality is present in sub-clinical groups with many negative schizotypal traits. The evidence suggests that in most situations the cognitive system of those with many negative schizotypal traits does not differentiate between positively and negatively valenced stimuli. Although the nature of such blunted reaction is speculative, it could be due mechanisms that override automatic emotion cue processing. However, under conditions of the affective priming paradigm where the processing of prime stimuli is unavoidable, the high scoring negative schizotypy group displayed a processing preference to negatively valenced cue stimuli. The results from experiments 3, 4 and 5 also indicate that the low introvertive anhedonia group have a processing preference for positively valenced emotional cue stimuli. This processing preference was robust and was observed under conditions of three different experimental paradigms.

It would seem that pleasure stimuli do not have the same ‘attention’ grabbing value for the high introvertive anhedonia group that they have for the low introvertive anhedonia group. Negative schizotypy might therefore be associated with a reduction in the reward value of positive stimuli. Such a reduction could result in or result from a global executive deficit that disrupts the ability to form and use contextual rules that guide behaviour. Reductions in the value of positive stimuli might reduce the ability of rewarding stimuli to enter into stimulus response associations during learning. On the other hand, a disruption in the ability to form rules that guide behaviour and the acquisition of stimulus response associations might result in positive stimuli not acquiring high reward value. Experiment 6 therefore attempted to determine which of these accounts best characterises the absence of
a positive cue processing preference of the high introvertive anhedonia group by examining whether their context processing deficit, identified in experiment 1 and 2, causes, or results from reductions in the processing of positive emotion cue stimuli.

Experiment 6 therefore addressed objective 3 of the thesis by examining the impact of positive and negative valenced stimuli on the learning of stimulus-outcome associations during the acquisition of bi-conditional discriminations (stage 1, training) and during positive and negative prediction errors generated during a revaluation stage (stage 2, revaluation). This enabled the examination of whether outcome valence differentially influences executive cognitive processes involved in the acquisition of a complex conditional discrimination in high and low introvertive anhedonia possible. It further enabled the examination of possible group differences that positive and negatively valenced outcomes have in supporting the acquisition of new associations.

The results of stage 1 (training) suggested that both the high and low introvertive anhedonia groups acquired the biconditional discrimination to the same degree. This indicated equivalent functioning in both groups of the cognitive mechanisms purported to underpin the acquisition of conditional discriminations. During stage 2 (revaluation) the low introvertive anhedonia group were immediately behaviourally sensitive to negative prediction error, when a stimulus→reward association was revaluated to a stimulus→punishment association. In contrast, the high introvertive anhedonia group showed no apparent sensitivity to either positive or negative prediction errors. The high introvertive anhedonia group were equivalently insensitive to the revaluation of a stimulus→reward association to a stimulus→punishment association, and to when a stimulus→punishment association was revaluated to a stimulus→reward association.

One interpretation of the immediate insensitivity of the high introvertive anhedonia group to positive and negative prediction errors, generated during revaluation in stage 2, is that weak associations were formed during biconditional discrimination training in stage 1. Weak associations underpinning the bi-conditional discrimination would implicate a global but subtle context processing deficit in the high introvertive anhedonia group reflecting reduction in the ability of positive and negative outcomes to support the development of stimulus–outcome associations. Such an interpretation would also implicate the formation of selectively weak associations in the low introvertive anhedonia group for compounds with aversive outcomes during stage 1 (training). This would result in weak positive prediction error signalling during stage 2 (revaluations) and the absence of behavioural
adjustment. In contrast, the development of stronger associations for compounds with appetitive outcomes in stage 1 might have resulted in large negative prediction errors during revaluation in stage 2 thereby resulting in immediate behavioural adjustment. Such interpretations are based on differences between the high and low introvertive anhedonia groups in the strength of associations that underpin the biconditional discrimination. However, there was no evidence in the current experiment that these differences existed.

An alternative interpretation is that the selective sensitivity of the low introvertive anhedonia group to negative prediction error might reflect enhanced signal detection and processing. Negative prediction error signals may have ‘gated’ the updating of contextual representations enabling the inhibition of the appetitive outcome representation and the strengthening of the aversive outcome representation. The insensitivity of the high introvertive anhedonia group to both negative and positive prediction error could therefore reflect a failure to detect prediction error signals, a failure of such a signal to update representations or deficits in representing reward value.

The 6 experiments summarised above addressed 3 main objectives: 1) explore the possibly of a generalised executive deficit in introvertive anhedonia, 2) explore the possibility of an emotion cue processing deficit in the introvertive anhedonia, and 3) explore possibility of an interaction between executive functioning and emotion cue processing in introvertive anhedonia. The results of these 6 experiments suggest that high introvertive anhedonia is associated with 1) a central executive dysfunction that can be characterised as a deficit in context processing, 2) the absence, in most cases, of differential processing of positively or negatively valenced cue stimuli, and 3) immediate insensitivity of positive and negative prediction errors to support new learning.

5.2: Synthesis and Theoretical Implications

The results presented in this thesis have a number of theoretical implications. They indicate that executive dysfunction, specifically characterised as a context processing deficit, is present in sub-clinical groups with many negative schizotypal traits. These findings along with the observation of executive dysfunction in the negative symptoms of schizophrenia (Ventura et al., 2009; Dibben, et al., 2009) suggest that context processing deficits might be a cognitive endophenotype of the negative dimension of schizophrenia. The identification of an endophenotype further implicates it as a core element in
schizophrenia. Deficits of the central executive are likely to affect all sub cognitive processes and might contribute to the breakdown into schizophrenia, and to a range of schizophrenia symptoms.

Context processing deficits in schizophrenia have typically been proposed to underpin positive and disorganised symptoms (e.g. Hemsley, 2005). However, a context processing deficit that represents an endophenotype of the negative dimension would imply that negative traits and symptoms must precede or co-occur with the presentation of hallucination and delusions. Despite Hemsley (2005) suggesting that a deficit in context processing might be central in schizophrenia by causing a range of positive and disorganised symptoms, no suggestion was made as to how such a deficit might contribute to the negative affective symptoms of schizophrenia. However, data collected from the current investigation provides some suggestions regarding the fundamental cognitive processes involved in negative schizotypy and by extension negative schizophrenic symptoms.

Evidence from the current thesis indicates that introvertive anhedonic traits are associated with an executive processing deficit (experiment 1 and 2) and an emotion cue processing deficit that is characterised by the absence of a processing preference to either positive or negative emotional cues (experiment 3 and 4) and in certain specific situations, a processing preference for negative emotion cues (experiment 5). The results of experiment 6, however, suggest that these cognitive and emotion cue deficits might be related.

Results from experiment 6 indicated that the high introvertive anhedonia group was insensitive to positive and negative predication errors. Prediction errors might gate the updating of context representations (O’Rielly, Braver & Cohen, 1999). The examination of dopamine neuron activity to prediction errors in animals and theoretical formal accounts of prediction error learning provided the framework from which to generate hypotheses regarding the deficits underpinning the performance of the high introvertive anhedonia group to prediction errors. It was theorised that the insensitivity to positive and negative prediction error might occur for four possible reasons: 1) weak associations formed during biconditional discrimination training would result in weak prediction error signals during revaluation (see Rescorla, 2000), 2) prediction error signals were poorly detected (see Holroyed and Coles, 2002), 3) prediction error signals are unable to update context representations or 4) reward value of stimuli was not represented.
The formation of weak associations during biconditional discrimination training could have resulted from the insensitivity of those with many introvertive anhedonic traits to both positive and negative valenced stimuli seen in experiment 3 and 4. High introvertive anhedonics might have a weakness in the prediction error signal that feeds back from valenced outcomes. This possibility is supported by informal inspection of the biconditional discrimination acquisition curve, which suggests that the low introvertive anhedonia group had stronger associations of half the discrimination that was supported by an appetitive outcome. However, alternative accounts must be considered given the absence of statistical evidence supporting this proposition.

As the high and low introvertive anhedonic groups acquired the biconditional discrimination to the same degree then the insensitivity of the high introvertive anhedonia group to positive and negative predication errors must result from deficits in predication error signal detection, or reductions in the ability to use such signals to update context representations. A further possibility is that the reward value of stimuli might not be adequately represented in the orbitofrontal cortex (OFC). Any of these failures might result in positive cues having reduced salience for the high introvertive anhedonia group. Positive stimuli would therefore be ineffective as reinforcers and be unable to support the development of new associations. Positively valenced stimuli might therefore not capture or demand detailed processing by those with many negative schizotypal traits. This interpretation would account for findings of anhedonia being associated with reduced sensitivity to reward (Applegate et al., 2009; Germans and Kring 2000; Horan et al., 2006) but intact subjective emotional experience of consuming rewarding stimuli (Germans and Kring 2000). Those with many negative schizotypal traits are able to experience and express emotions but reductions in the ability of appetitive stimuli to support learning could result in emotional cues losing or not acquiring high salience.

The inability of appetitive stimuli to support learning would impact the ability to respond flexibly to new and changing situations and could underpin the executive dysfunction of the high introvertive anhedonia groups observed in experiment 1 and 2. For example, in experiment 2 the high introvertive anhedonia group had difficulties adapting to high-conflict incongruent Stroop trials. This could reflect a failure of appetitive outcomes to support the learning of the irrelevance of the word dimension of incongruent Stroop colour word stimuli. In this instance, the appetitive outcomes might be the anticipated satisfaction of responding correctly to colour. Repeated instances such as this might eventually result in introvertive anhedonics learning that internal and external appetitive cues are irrelevant.
so that emotional cues subsequently lose their salience, as seen in experiment 3, 4 and 5.

Results from experiment 6 further indicated that those who have atypically none or very few introvertive anhedonia traits were immediately sensitive to negative prediction errors but immediately insensitive to positive prediction errors. This could result from 4 possible causes; 1) selectively strong associations with positive outcomes but weak associations with negative outcomes formed during biconditional discrimination training would result in strong negative prediction error signalling but weak positive prediction error signalling during revaluations (e.g. Rescorla, 2000), 2) particular sensitivity to the detection of negative prediction error signals (e.g. Holroyed and Coles 2002), 3) the updating of cortex processing representations being highly sensitive to inhibitory gating signals, 4) the reward value of appetitive outcomes being strongly represented in the orbitofrontal cortex (OFC) (e.g. Kringlebach, 2005).

The formation of selectively strong associations with positive outcomes during biconditional discrimination training might have resulted from the processing preference of the low introvertive anhedonia group to positive emotion cue stimuli (see experiment 3, 4 and 5). The preferential processing of positively valenced stimuli could indicate that appetitive stimuli are highly salient thereby increasing their effectiveness as reinforcers and easing the formation of associations. However, the absence of statistical evidence supporting this proposition means that alternative account must be considered. The low introvertive anhedonia group could have an acute and selective sensitivity for inhibitory gating signals to update PFC representations. This might enable the low introvertive anhedonia group to rapidly learn when positive outcomes change to negative outcomes. This ability to rapidly detect when good outcomes become bad might enable the avoidance of negative stimuli thereby reducing exposure to negative events. The ability to avoid negative stimuli might reciprocally increase the salience of positive stimuli resulting in greater positive hedonic experiences.

This interpretation would imply that the ability to rapidly detect negative outcomes could be the cause of the positive emotion cue processing preference of the low introvertive anhedonia group observed in experiments 3, 4 and 5. Positive emotion cues might have had heightened salience and eased the formation of strong associations in experiment 6. However, the increased salience of positive emotion cues might result from a cognitive system that is particularly sensitive to the detection of negative stimuli. Such a function might underpin the hedonism that would be expected in those with none or very few
introvertive anhedonic traits, by enabling the rapid avoidance of negative stimuli that would reduce their impact on other cognitive systems. The absence of such an adaptive function in the high introvertive anhedonia group might increase environmental stress by reducing the ability to rapidly adapt resulting in perseveration and an increase in the impact of negative stimuli. Such a failure could plausibly be the core aetiological mechanism in the development of schizophrenia that represents the interaction of environmental stress with a schizophrenia diathesis.

5.3: Methodological Problems and Limitations of the Current Research

The most prominent methodological limitation of the thesis appears to have been the inability to completely isolate the schizotypal trait dimension under investigation. Effect sizes are likely to be small when examining schizotypal traits in individuals recruited from sub-clinical groups in the ‘normal’ population. Examining cognitions of groups from the extremes of a schizotypy trait dimension is likely to increase experimental power. However, such a strategy is also likely to exaggerate the effects of co-occurring traits that are not the focus of the current investigation. For example, in all experiments of the current thesis, except experiment 5, the high introvertive anhedonia group not only had significantly higher introvertive anhedonia (i.e. negative schizotypy) scores than the low group but also significant higher unusual experiences (i.e. positive schizotypy) scores. Difference in cognition between the two groups can not therefore be only attributed to differences in introvertive anhedonia but also differences in unusual experiences.

It is worth noting that in all of cases, the levels of unusual experiences for both the high and low introvertive anhedonia groups were within the 2nd and 3rd quartiles of the normed unusual experiences distribution (see Table 5). Therefore, the high introvertive anhedonia groups recruited in the current study had an atypically high number of negative schizotypal traits but a ‘normal’ or medium number of positive schizotypal traits. Furthermore, the low introvertive anhedonia group had an atypically low number of negative schizotypal traits but also a ‘normal’ or medium number of positive schizotypal traits. Therefore, despite the differences in unusual experiences between the high and low introvertive anhedonia groups, both groups had unusual experiences within the ‘normal’ or medium range.
Statistical procedures provided further evidence that effects of interest were unrelated to other schizotypal trait dimensions that were not the focus of the current investigation. In all experiments, multiple regression and logistic regression analyses established that effects of interest were unrelated to unusual experience, impulsive nonconformity and cognitive disorganisation scores of the recruited samples.

A further limitation of the investigation, which is also related to the recruitment strategy, is the inability of the current investigation to examine the experimental effects under consideration in the other O-LIFE schizotypal trait dimensions (i.e. unusual experiences, cognitive disorganisation and impulsive non-conformity). Using the same analyses of extremes, the comparison of effects in introvertive anhedonia and unusual experiences would involve the recruitment of a sample of extreme scoring high and low introvertive anhedonia groups and another sample of extreme scoring high and low unusual experiences groups. This would have involved a significantly larger sample resulting in an increased burden in experimental testing and further constraining the number of experiments and therefore the number of research questions addressed in the current thesis. However, such a recruitment strategy might be advantageous in future research when examining how levels of different schizotypal traits might interact.

Additionally, the current investigation was unable to identify or explain the specific cognitive processes that might be involved in the observed effects. For example, although a context processing deficit can account for results of the high introvertive anhedonia group in experiment 1 and 2, the precise processes underpinning the effects are unknown. A failure to display behavioural adaptation to high-conflict trials in experiment 2 could result from either a failure to generate conflict detection signals, a reduced ability to implement conflict detection signals to enhance contextual representations or a reduction in the ability to use representations of context to enhance goal directed behaviours. Furthermore, experiments 3, 4 and 5 suggest that the high introvertive anhedonia group might use a repressor strategy in certain situations to avoid the processing of valenced stimuli. However, the precise nature of this strategy can only be speculated. Finally, experiment 6 indicates how emotion cue processing preferences in the high and low introvertive anhedonia group might influence learning. However, it does not identify the precise cognitive processes that underpin different effects in the high and low introvertive anhedonia group. For example, the inability of the high introvertive anhedonia group to adapt to positive or negative prediction errors could be due to either the generation of weak prediction error signals, the inability to detect prediction error signals by a conflict
monitor, the inability of prediction error signals to gate the updating of context representations or failures in representing the reward value of appetitive stimuli. Despite the limitations of these studies to specifically identify the precise cognitive processes that underpin observed effects, their analysis did generate further research questions that could be addressed in future investigations.

5.4: Future Research

The thesis generated a number of new research questions that could be addressed by further research. Both experiment 2 and 6 suggest that the failure of the high introvertive anhedonia group to behaviourally adapt to conflict detection signals might be due to either failures of a mismatch or error monitor or a failure of these conflict monitoring signals to update or enhance contextual representations. This therefore presents two avenues for future research. The first would be to explore functions of the conflict monitor in high and low introvertive anhedonia groups. A conflict monitor could be assessed through the examination of event related negativity (ERN), an electroencephalography (EEG) event related waveform that is thought to be sensitive to the detection of conflict or errors (see Yeung, Botvinick & Cohen, 2004 for review). The second would be to further examine the updating context representations in high and low introvertive anhedonia groups. This could be accomplished using a number of experimental tasks, such as the CPT-AX task, n-back task or Wisconsin card-sorting task.

One of the implications of experiment 3, 4 and 5 is that the high introvertive anhedonia group might use some repressor strategies to inhibit or override the processing of negative emotional cues. This could be further explored by assessing both the conscious and subliminal allocation of processing resources to the processing of emotional cues. The examination of the conscious reallocation of processing resources could use procedures similar to those in experiment 2 where the effects of trial-by-trial adjustments in resource allocation to the processing of emotional cues could be observed. Subliminal processes could be examined by presenting emotional stimuli implicitly for brief periods such that top down cognitive control processes are uninvolved. This might be accomplished by adapting the affective priming paradigm so that primes are presented below the threshold for conscious detection (i.e. <20ms, see Williams et al., 2006 for discussion of subliminal emotional stimulus detection thresholds). The observation of affective priming congruency effects under these conditions would suggests that conflict monitoring is
occurring without conscious detection of the conflicting prime stimulus and therefore independent of top down processes.

A further avenue of research would be to dissociate effects observed in high introvertive anhedonia (i.e. negative schizotypy) with a group who are high on unusual experiences (positive schizotypy). The analyses of experiment 1 suggested that presenting a majority proportion of colour word Stroop stimuli than neutral stimuli (i.e. XXXX) resulted in increased allocation of resources to colour naming and decreased resources to word reading. Essentially, such manipulations were argued to enhance context processing (i.e. respond to colour not word) but also enhance inhibitory processes (i.e. do not respond to word).

The low introvertive anhedonia group were presumed to have both intact context processing and inhibitory processing. However, it was argued that a context processing deficit in the high introvertive anhedonia group would resulted in abnormally long colour naming reaction times to neutral Stroop stimuli (i.e. XXXX) and the production of a small Stroop interference effect. There is some evidence suggesting that deficits in inhibition are associated with positive schizotypy but not negative schizotypy (e.g. Shrira & Tsakanikos, 2009). Positive and negative trait schizotypy might therefore be associated with specific but different central executive dysfunctions. Such dissociation could be examined using the procedures outlined above. A context processing deficit but intact inhibitory processes in a high introvertive anhedonia (i.e. negative schizotypy) group might result in a particularly small Stroop interference effect. However, intact context processing but deficits in inhibition in a high unusual experiences (i.e. positive schizotypy) group might result in a particularly large Stroop interference effect.

5.5: Conclusions

The studies reported in the thesis addressed 3 major objectives; 1) explore the possibility of a generalised executive deficit in introvertive anhedonia, 2) explore the possibility of an emotion cue processing deficit in the introvertive anhedonia, and 3) explore possibility of an interactions between executive functioning and emotion cue processing in introvertive anhedonia. The results of these 6 experiments suggest that high introvertive anhedonia is associated with 1) a central executive dysfunction that can be characterised as a specific deficit in context processing, 2) blunted responses to positively and negatively valenced
stimuli, and 3) insensitivity of appetitive or aversive outcomes to update context representations and support new leaning. The results of these 6 experiments further suggest that low introverted anhedonic groups are associated with 1) intact central executive functioning and context processing, 2) a positive emotion cue processing preference, and 3) a selective sensitivity of aversive outcomes to update context representations and support new leaning.

The ability of the high introverted anhedonia group to rapidly detect negative outcomes might be the cause of their positive emotion cue processing bias. Such a function could underpin the hedonism that might be expected in individuals with none or very few introverted anhedonic traits by enabling the rapid avoidance of aversive stimuli thereby reducing their impact on other cognitive systems. The absence of such adaptive functions in the high introverted anhedonia group might increase environmental stress by reducing the ability to rapidly adapt resulting in perseveration and an increase in the impact of negative stimuli. Such a failure might be the core aetiological mechanism that represents the interaction of environmental stress with a schizophrenia diathesis that results in the decompensation into clinical schizophrenia.
6: References


7: Appendices
7.1: Appendix 1:

Regression tables
### Experiment 1

Table A1.1
Results of the logistic regression analyses with the dichotomous measure of error Stroop interference as the dependant variable.

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<tr>
<td>Unusual Experiences</td>
<td>-.027</td>
<td>.053</td>
<td>.270</td>
<td>1</td>
<td>.603</td>
<td>.973</td>
<td>.878</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>-.041</td>
<td>.090</td>
<td>.208</td>
<td>1</td>
<td>.648</td>
<td>.960</td>
<td>.804</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>.000</td>
<td>.069</td>
<td>.000</td>
<td>1</td>
<td>.999</td>
<td>1.000</td>
<td>.874</td>
</tr>
</tbody>
</table>

### Experiment 2

Table A1.2
Results of the multiple regression analyses with the reaction time measure of Stroop interference as the dependant variable.

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>19.28</td>
<td>13.46</td>
<td>-.21</td>
<td>.158</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>4.54</td>
<td>4.10</td>
<td>.15</td>
<td>.274</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-0.39</td>
<td>2.91</td>
<td>-.20</td>
<td>.894</td>
</tr>
</tbody>
</table>

Table A1.3
Results of the logistic regression analyses with the dichotomous measure of error Stroop interference as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>sig</th>
<th>Exp(B)</th>
<th>95.0% CI EXP(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>.053</td>
<td>.047</td>
<td>1.281</td>
<td>1</td>
<td>.258</td>
<td>1.054</td>
<td>.962</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>-.131</td>
<td>.083</td>
<td>2.467</td>
<td>1</td>
<td>.116</td>
<td>.877</td>
<td>.745</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>.042</td>
<td>.056</td>
<td>.564</td>
<td>1</td>
<td>.453</td>
<td>1.043</td>
<td>.934</td>
</tr>
</tbody>
</table>
Table A1.4
Results of the multiple regression analyses with the reaction time measure of adjustment to conflict as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>17.06</td>
<td>13.37</td>
<td>0.19</td>
<td>.208</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>4.98</td>
<td>4.04</td>
<td>0.17</td>
<td>.224</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-2.47</td>
<td>2.85</td>
<td>-0.13</td>
<td>.391</td>
</tr>
</tbody>
</table>

Table A1.5
Results of the logistic regression analyses with the dichotomous measure of error adjustment to conflict as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>sig</th>
<th>Exp(B)</th>
<th>95.0% CI</th>
<th>EXP(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>.002</td>
<td>.051</td>
<td>.001</td>
<td>1</td>
<td>.975</td>
<td>1.002</td>
<td>.907</td>
<td>1.106</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>.048</td>
<td>.088</td>
<td>.295</td>
<td>1</td>
<td>.587</td>
<td>1.049</td>
<td>.883</td>
<td>1.246</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-.077</td>
<td>.063</td>
<td>1.500</td>
<td>1</td>
<td>.221</td>
<td>.926</td>
<td>.819</td>
<td>1.047</td>
</tr>
</tbody>
</table>

Experiment 3

Table A1.6
Results of the multiple regression analyses with the reaction time measure of emotional valence effects (RT positive stimuli minus RT negative stimuli)

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>0.15</td>
<td>1.13</td>
<td>0.23</td>
<td>.897</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>-1.39</td>
<td>1.83</td>
<td>-0.12</td>
<td>.450</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-1.03</td>
<td>1.40</td>
<td>-0.12</td>
<td>.465</td>
</tr>
</tbody>
</table>
Table A1.7
Results of the multinomial logistic regression analyses with the dichotomised measure of error emotional valence effects as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>sig</th>
<th>Exp(B)</th>
<th>95.0% CI EXP(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Errors to negative &gt; errors to positive</td>
<td>Unusual Experiences</td>
<td>.034</td>
<td>.069</td>
<td>.238</td>
<td>1</td>
<td>.626</td>
<td>.1034 .903 1.185</td>
</tr>
<tr>
<td></td>
<td>Impulsive Nonconformity</td>
<td>.180</td>
<td>.128</td>
<td>1.970</td>
<td>1</td>
<td>.160</td>
<td>1.197 .931 1.540</td>
</tr>
<tr>
<td></td>
<td>Cognitive Disorganisation</td>
<td>-.081</td>
<td>.089</td>
<td>.829</td>
<td>1</td>
<td>.362</td>
<td>.922 .775 1.098</td>
</tr>
<tr>
<td>Errors to positive &gt; errors to negative</td>
<td>Unusual Experiences</td>
<td>-.003</td>
<td>.066</td>
<td>.002</td>
<td>1</td>
<td>.962</td>
<td>.997 .875 1.135</td>
</tr>
<tr>
<td></td>
<td>Impulsive Nonconformity</td>
<td>-.244</td>
<td>.123</td>
<td>3.961</td>
<td>1</td>
<td>.047</td>
<td>.783 .616 .996</td>
</tr>
<tr>
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<td>Cognitive Disorganisation</td>
<td>.095</td>
<td>.083</td>
<td>1.304</td>
<td>1</td>
<td>.253</td>
<td>1.099 .934 1.294</td>
</tr>
</tbody>
</table>

Note. reference category is: no difference in errors to positive and negative

Experiment 4

Table A1.8
Results of the multiple regression analyses with the index of attentional orientation with positively valenced stimuli (RT [dotNeutral, Neutral] minus mean RT [dotPositive, Neutral]) as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>-0.00005</td>
<td>0.00017</td>
<td>-.057</td>
<td>.754</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>-0.00005</td>
<td>0.00005</td>
<td>-.150</td>
<td>.348</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>0.00004</td>
<td>0.00004</td>
<td>.164</td>
<td>.348</td>
</tr>
</tbody>
</table>

Table A1.9
Results of the multiple regression analyses with the index of attentional orientation with negatively valenced stimuli (RT [dotNeutral, Neutral] minus mean RT [dotNegative, Neutral]) as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>-1.432</td>
<td>1.685</td>
<td>-.159</td>
<td>.400</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>.479</td>
<td>.479</td>
<td>.159</td>
<td>.323</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>.197</td>
<td>.384</td>
<td>.094</td>
<td>.611</td>
</tr>
</tbody>
</table>
Table A1.10
Results of the multiple regression analyses with the index of attentional disengagement with positively valenced stimuli (RT \([\text{dotNeutral, Positive}] \) minus mean RT \([\text{dotNeutral, Neutral}] \) as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>1.101</td>
<td>1.790</td>
<td>.113</td>
<td>.542</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>-.019</td>
<td>.496</td>
<td>-.006</td>
<td>.969</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-.723</td>
<td>.399</td>
<td>-.326</td>
<td>.077</td>
</tr>
</tbody>
</table>

Table A1.11
Results of the multiple regression analyses with the index of attentional disengagement with negatively valenced stimuli (RT \([\text{dotNeutral, Negative}] \) minus mean RT \([\text{dotNeutral, Neutral}] \) as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>-.274</td>
<td>1.585</td>
<td>-.030</td>
<td>.863</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>.871</td>
<td>.433</td>
<td>.310</td>
<td>.051</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-.052</td>
<td>.341</td>
<td>-.026</td>
<td>.879</td>
</tr>
</tbody>
</table>

**Experiment 5**

Table A1.12
Results of the multiple regression analyses with the reaction time measure of affective priming with positive targets (RT+ minus RT++) as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>.181</td>
<td>.293</td>
<td>.117</td>
<td>.541</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>.074</td>
<td>.068</td>
<td>.174</td>
<td>.283</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-.048</td>
<td>.052</td>
<td>-.166</td>
<td>.364</td>
</tr>
</tbody>
</table>
Table A1.13
Results of the multiple regression analyses with the reaction time measure of affective priming with negative targets (RT+ minus RT-) as the dependent variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>-7.10</td>
<td>7.07</td>
<td>-0.19</td>
<td>.321</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>-1.35</td>
<td>1.62</td>
<td>-0.13</td>
<td>.410</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>1.76</td>
<td>1.25</td>
<td>0.25</td>
<td>.166</td>
</tr>
</tbody>
</table>

Table A1.14
Results of the logistic regression analyses with the dichotomous measure of error affective priming effects for prime-target pairs with positive targets (error-+ vs. error++) as the dependent variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>sig</th>
<th>Exp(B)</th>
<th>95.0% CI EXP(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>.018</td>
<td>.058</td>
<td>.095</td>
<td>1</td>
<td>.757</td>
<td>1.018</td>
<td>.909</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>.129</td>
<td>.086</td>
<td>2.245</td>
<td>1</td>
<td>.134</td>
<td>1.138</td>
<td>.961</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-.061</td>
<td>.065</td>
<td>.895</td>
<td>1</td>
<td>.344</td>
<td>.941</td>
<td>.829</td>
</tr>
</tbody>
</table>

Table A1.15
Results of the logistic regression analyses with the dichotomous measure of error affective priming effects for prime-target pairs with negative targets (error+- vs. error--.) as the dependent variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>sig</th>
<th>Exp(B)</th>
<th>95.0% CI EXP(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>.075</td>
<td>.064</td>
<td>1.376</td>
<td>1</td>
<td>.241</td>
<td>1.078</td>
<td>.951</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>.153</td>
<td>.100</td>
<td>2.330</td>
<td>1</td>
<td>.127</td>
<td>1.165</td>
<td>.958</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-.089</td>
<td>.075</td>
<td>1.420</td>
<td>1</td>
<td>.233</td>
<td>.915</td>
<td>.790</td>
</tr>
</tbody>
</table>
Experiment 6

Table A1.16
Results of the multiple regression analyses with the measure of the effect of outcome valence on the acquisition of the discrimination

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>-.777</td>
<td>.487</td>
<td>-.236</td>
<td>.117</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>.032</td>
<td>.148</td>
<td>.031</td>
<td>.827</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>.041</td>
<td>.105</td>
<td>.059</td>
<td>.694</td>
</tr>
</tbody>
</table>

Table A1.17
Results of the logistic regression analyses with the dichotomous measure of positive prediction error learning as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>sig</th>
<th>Exp(B)</th>
<th>95.0% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>.014</td>
<td>.051</td>
<td>.078</td>
<td>1</td>
<td>.780</td>
<td>1.014</td>
<td>.899 - 1.072</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>-.045</td>
<td>.089</td>
<td>.258</td>
<td>1</td>
<td>.611</td>
<td>.956</td>
<td>.925 - 1.254</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-.073</td>
<td>.062</td>
<td>1.399</td>
<td>1</td>
<td>.237</td>
<td>.930</td>
<td>.896 - 1.110</td>
</tr>
</tbody>
</table>

Table A1.18
Results of the logistic regression analyses with the dichotomous measure of negative prediction error learning as the dependant variable

<table>
<thead>
<tr>
<th>Schizotypal Dimensions</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>sig</th>
<th>Exp(B)</th>
<th>95.0% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unusual Experiences</td>
<td>-.018</td>
<td>.045</td>
<td>.162</td>
<td>1</td>
<td>.687</td>
<td>.982</td>
<td>.899 - 1.072</td>
</tr>
<tr>
<td>Impulsive Nonconformity</td>
<td>.074</td>
<td>.078</td>
<td>.910</td>
<td>1</td>
<td>.340</td>
<td>1.077</td>
<td>.925 - 1.254</td>
</tr>
<tr>
<td>Cognitive Disorganisation</td>
<td>-.003</td>
<td>.055</td>
<td>.003</td>
<td>1</td>
<td>.956</td>
<td>.997</td>
<td>.896 - 1.110</td>
</tr>
</tbody>
</table>
7.2: Appendix 2:

Stroop stimulus blocks used in experiment 2
## Appendix 2a: Experiment 2 Stroop main stimulus block 1

Table A2.1
Stroop experiment 2 **Main Stimulus Block 1**

*Note.* Main stimulus block 1 contains 3 congruent and 2 incongruent unique sub-blocks of 8 Stroop colour word items. Sub-block items were presented in fixed pseudorandom order as they appear in the table.

<table>
<thead>
<tr>
<th>Sub-block condition</th>
<th>Word</th>
<th>Colour</th>
<th>Sub-block condition</th>
<th>Word</th>
<th>Colour</th>
<th>Sub-block condition</th>
<th>Word</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Congruent</strong></td>
<td>YELLOW</td>
<td>yellow</td>
<td><strong>Congruent</strong></td>
<td>GREEN</td>
<td>green</td>
<td><strong>Congruent</strong></td>
<td>BLUE</td>
<td>blue</td>
</tr>
<tr>
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<td>blue</td>
<td></td>
<td>YELLOW</td>
<td>yellow</td>
<td></td>
<td>RED</td>
<td>red</td>
</tr>
<tr>
<td></td>
<td>RED</td>
<td>red</td>
<td></td>
<td>GREEN</td>
<td>green</td>
<td></td>
<td>YELLOW</td>
<td>yellow</td>
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<tr>
<td></td>
<td>YELLOW</td>
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<td>green</td>
<td></td>
<td>BLUE</td>
<td>blue</td>
<td></td>
<td>RED</td>
<td>red</td>
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<tr>
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<td>blue</td>
<td></td>
<td>YELLOW</td>
<td>yellow</td>
<td></td>
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<td>green</td>
<td></td>
<td>BLUE</td>
<td>blue</td>
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<td>RED</td>
<td>red</td>
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<tr>
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<td>BLUE</td>
<td>blue</td>
<td></td>
<td>YELLOW</td>
<td>yellow</td>
<td></td>
<td>GREEN</td>
<td>green</td>
</tr>
<tr>
<td><strong>Incongruent</strong></td>
<td>GREEN</td>
<td>blue</td>
<td><strong>Incongruent</strong></td>
<td>BLUE</td>
<td>yellow</td>
<td><strong>Incongruent</strong></td>
<td>RED</td>
<td>red</td>
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<tr>
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<td>YELLOW</td>
<td>green</td>
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<tr>
<td></td>
<td>BLUE</td>
<td>green</td>
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<td>GREEN</td>
<td>red</td>
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<td>BLUE</td>
<td>green</td>
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<tr>
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<tr>
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<td>green</td>
</tr>
<tr>
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<tr>
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<tr>
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<td></td>
<td>BLUE</td>
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</tr>
</tbody>
</table>
Appendix 2b: Experiment 2 Stroop main stimulus block 2

Table A2.2
Stroop experiment 2 **Main Stimulus Block 2**
*Note.* Main stimulus block 2 contains 3 incongruent and 2 congruent unique sub-blocks of 8 Stroop colour word items. Sub-block items were presented in fixed pseudorandom order as they appear in the table.

<table>
<thead>
<tr>
<th>Sub-block condition</th>
<th>Word</th>
<th>Colour</th>
<th>Sub-block condition</th>
<th>Word</th>
<th>Colour</th>
</tr>
</thead>
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<td>YELLOW</td>
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</tr>
<tr>
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<tr>
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</tbody>
</table>


Appendix 2c: Experiment 2 Stroop main stimulus block 3

Table A2.3
Stroop experiment 2 Main Stimulus Block 3
Note. Main stimulus block 3 contains 3 congruent and 2 incongruent unique sub-blocks of 8 Stroop colour word items. Sub-block items were presented in fixed pseudorandom order as they appear in the table.

<table>
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<th>Sub-block condition</th>
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<th>Sub-block condition</th>
<th>Word</th>
<th>Colour</th>
<th>Sub-block condition</th>
<th>Word</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
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<td>Congruent</td>
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<tr>
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<tr>
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</tr>
<tr>
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<td>Blue</td>
</tr>
<tr>
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</tr>
</tbody>
</table>


Appendix 2d: Experiment 2 Stroop main stimulus block 4

Table A2.4
Stroop experiment 2 Main Stimulus Block 4
Note. Main stimulus block 4 contains 3 incongruent and 2 congruent unique sub-blocks of 8 Stroop colour word items. Sub-block items were presented in fixed pseudorandom order as they appear in the table.

<table>
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<th>Sub-block condition</th>
<th>Word</th>
<th>Colour</th>
<th>Sub-block condition</th>
<th>Word</th>
<th>Colour</th>
<th>Sub-block condition</th>
<th>Word</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
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<td>YELLOW</td>
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</tbody>
</table>
7.3: Appendix 3:

Word stimulus selection and norming procedure
Introduction.

The thesis explored attentional biases to emotional cues in introvertive anhedonia. Previous studies have shown that attentional biases can be observed when word stimuli reflect an individual’s specific pathology such as anxiety or depression (Willimas, et al., 1996). Anhedonia can reflect the absence of pleasure from both physical and or social sources. The use of pleasure and threat word cues that relate to social and physical situations might therefore provide greater sensitivity in detecting and examining specific attentional biases in anhedonia.

A number of studies have made distinctions social and physical threat and pleasure (e.g. Fox 1995). However, they make no reference to the method employed in categorising positive and negative word into social and physical categories.

The goal of stimulus selection was to use objective norming procedures to generate a pool of highly arousing positively and negatively valenced words that relate to a person’s physical self and a pool of highly arousing positively and negatively valenced words that related to a person’s social self. The affective norms for English words (ANEW) (Bradley and Lang, 1999) list was used for initial word selection as it consists of over 1000 words previously normed on a 9 point scale on valence, arousal and dominance dimensions.

Phase 1: Initial word selection

All words that had an arousal rating of >5, and therefore considered highly arousing, and also having a valence rating of either >=7 (positive) or =<3 (negative) were selected from the ANEW list. This generated 161 highly arousing negatively valenced words (Table A5) and 178 highly arousing positively valenced words (Table A6).

A preliminary judging phase was intended to reduce the number of words to a more manageable level. Five judges were therefore asked to rate each of the 161 positively valenced and 178 negatively valenced words on whether they related to their social world, physical world or some other category. Words that had majority agreement (i.e. 3 or greater) for belonging to any one category and had a word length longer than three characters were selected for norming and statistical analyses in phase 2. This preliminary judging phase resulted in the selection of 80 negatively valenced words and 86 positively valenced words, which are presented in Table A7 and A8.

Phase 2: Further word category norming with a larger sample

Twenty new judges who were naïve to phase 1 were presented with the 80 negatively valenced and 86 positively valenced words (Table A3 and A4) that were generated from preliminary judging in phase 1. As in phase 1, these 20 participants were asked to read each word and indicate whether they thought that the word related to their physical world, social world or some other category.

Phase 3: Chi-square distribution analysis

The category ratings of the 20 participants for each of the 80 negatively valenced and 86 positively valenced words were analysed using chi-square goodness of fit test. Some of
the individual words received ratings for all three categories (i.e. social & physical & other) while other words only received two (e.g. social & other). The distribution of responses for some of the words would therefore have 2 degrees of freedom while other only had 1. The chi-square goodness of fit test is sensitive to the degrees of freedom, therefore, each word was given one additional pseudo judgment for the least occurring category. This equalised the degrees of freedom for the response distribution of all words and made word selection based on the chi-square probability value more appropriate (see Table A7 and A8).

**Results: Final word list**

A word was selected for potential use in the study if the number of ratings in the three categories (social, physical or other) significantly differed. The word was then assigned to the category with the significantly greater number of ratings. Table A9 below presents the negatively (n=21) and positively (n=27) valenced words that were categorised as relating to peoples social world. Table A10 below presents the negatively (n=20) and positively (n=13) valenced words that were categorised as relating to peoples physical world.

**Confirmatory analyses**

The ANEW valence and arousal ratings for each positive social, negative social, positive physical and negative physical words are plotted in Figure A1. Figure A1 indicates that all words had an arousal rating of >5 and that all positive words had a valence rating of =>7 and all negative words had a valence rating of =<3. Mean valence and arousal for the positive social, negative social, positive physical and negative physical categories were compared using t-tests. The results of these are presented in matrix tables A11 and 12.

Table A11 presents the mean valence ANEW ratings for the positive social, negative social, positive physical and negative physical word categories. The table also presents the t-tests comparing means between all categories. It indicates that the positive categories had significantly higher valence ratings that negative categories. It also indicated that the positive social and positive physical categories did not have significantly different valence ratings. However, the negative physical category had a significantly greater negative valence rating than the negative social category.

Table A12 presents the mean arousal ANEW ratings for the positive social, negative social, positive physical and negative physical and t-tests of all category comparisons. No significant differences were observed between any of the categories mean arousal ratings indicating that all categories had comparable arousal ratings.
Table A3.1
161 ANEW words that have a negative valence rating of =< 3 and an arousal rating of >5. These words were subjected to preliminary judging by 5 participants in phase 1

<table>
<thead>
<tr>
<th>Abduction</th>
<th>Burial</th>
<th>Despairing</th>
<th>Frustrated</th>
<th>Jealousy</th>
<th>Penalty</th>
<th>Seasick</th>
<th>Toothache</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abuse</td>
<td>Burn</td>
<td>Despise</td>
<td>Gangrene</td>
<td>Killer</td>
<td>Pervert</td>
<td>Selfish</td>
<td>Toxic</td>
</tr>
<tr>
<td>Accident</td>
<td>Cancer</td>
<td>Destroy</td>
<td>Garbage</td>
<td>Lie</td>
<td>Pollute</td>
<td>Sin</td>
<td>Traitor</td>
</tr>
<tr>
<td>Ache</td>
<td>Cockroach</td>
<td>Detest</td>
<td>Guillotine</td>
<td>Loneliness</td>
<td>Prison</td>
<td>Sinful</td>
<td>Tragedy</td>
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<tr>
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<td>Devil</td>
<td>Guilty</td>
<td>Profit</td>
<td>Prison</td>
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<td>Trauma</td>
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<td>Hate</td>
<td>Loser</td>
<td>Punishment</td>
<td>Slaughter</td>
<td>Trauma</td>
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<tr>
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<td>Crime</td>
<td>Disgusted</td>
<td>Hated</td>
<td>Lost</td>
<td>Putrid</td>
<td>Slap</td>
<td>Troubled</td>
</tr>
<tr>
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<td>Crisis</td>
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<td>Mad</td>
<td>Quarrel</td>
<td>Slave</td>
<td>Tumour</td>
</tr>
<tr>
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<td>Crucify</td>
<td>Displeased</td>
<td>Hell</td>
<td>Malice</td>
<td>Rabies</td>
<td>Slime</td>
<td>Ugly</td>
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<tr>
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<td>Cruel</td>
<td>Distressed</td>
<td>Helpless</td>
<td>Massacre</td>
<td>Rage</td>
<td>Smallpox</td>
<td>Ulcer</td>
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<tr>
<td>Anguished</td>
<td>Crushed</td>
<td>Divorce</td>
<td>Horror</td>
<td>Measles</td>
<td>Rape</td>
<td>Starving</td>
<td>Unfaithful</td>
</tr>
<tr>
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<td>Dreadful</td>
<td>Hostile</td>
<td>Menace</td>
<td>Regretful</td>
<td>Stress</td>
<td>Upset</td>
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<td>Dead</td>
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<td>Rejected</td>
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<td>Vandal</td>
</tr>
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<td>Mistake</td>
<td>Riot</td>
<td>Suicide</td>
<td>Venom</td>
</tr>
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<td>Deceit</td>
<td>Execution</td>
<td>Infection</td>
<td>Morbid</td>
<td>Roach</td>
<td>Surgery</td>
<td>Victim</td>
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<td>Injury</td>
<td>Murderer</td>
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<td>Syphilis</td>
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<td>Rude</td>
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<td>Vomit</td>
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<td>Insult</td>
<td>Nightmare</td>
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<td>Terrified</td>
<td>War</td>
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<td>Jail</td>
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<td>Thief</td>
<td>Wicked</td>
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<td></td>
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<td></td>
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<td>Wounds</td>
</tr>
</tbody>
</table>
Table A3.2
178 ANEW words that have a positive valence rating of $\geq 7$ and an arousal rating of $>5$. These words were subjected to preliminary judging by 5 participants in phase 1.

<table>
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<th>Acceptance</th>
<th>Caress</th>
<th>Ecstasy</th>
<th>Gold</th>
<th>Intimate</th>
<th>Lucky</th>
<th>Proud</th>
<th>Sunlight</th>
</tr>
</thead>
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<td>Elated</td>
<td>Good</td>
<td>Intercourse</td>
<td>Magical</td>
<td>Puppy</td>
<td>Sunrise</td>
</tr>
<tr>
<td>Admired</td>
<td>Champ</td>
<td>Engaged</td>
<td>Graduate</td>
<td>Jewel</td>
<td>Masterful</td>
<td>Rescue</td>
<td>Surprised</td>
</tr>
<tr>
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<td>Champion</td>
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<td>Greet</td>
<td>Joe</td>
<td>Memories</td>
<td>Respect</td>
<td>Sweetheart</td>
</tr>
<tr>
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<td>Erotic</td>
<td>Grin</td>
<td>Jolly</td>
<td>Merry</td>
<td>Romantic</td>
<td>Talent</td>
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<tr>
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<td>Handsome</td>
<td>Joy</td>
<td>Millionaire</td>
<td>Riches</td>
<td>Terrific</td>
</tr>
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<td>Christmas</td>
<td>Exercise</td>
<td>Happy</td>
<td>Joyful</td>
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Table A3.4
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NOTE. The Table also includes these words ANEW valence and arousal ratings also included.

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<td>2.63</td>
<td>6.04</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Hopeful</td>
<td>7.10</td>
<td>5.78</td>
<td>Fraud</td>
<td>2.67</td>
<td>5.75</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Comedy</td>
<td>8.37</td>
<td>5.85</td>
<td>Malice</td>
<td>2.69</td>
<td>5.86</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Silly</td>
<td>7.41</td>
<td>5.88</td>
<td>Wicked</td>
<td>2.69</td>
<td>6.09</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Honour</td>
<td>7.66</td>
<td>5.90</td>
<td>Annoy</td>
<td>2.74</td>
<td>6.49</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>People</td>
<td>7.33</td>
<td>5.94</td>
<td>Crisis</td>
<td>2.74</td>
<td>5.44</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Joyful</td>
<td>8.22</td>
<td>5.98</td>
<td>Offend</td>
<td>2.76</td>
<td>5.56</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Elated</td>
<td>7.45</td>
<td>6.21</td>
<td>Menace</td>
<td>2.88</td>
<td>5.52</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Leader</td>
<td>7.63</td>
<td>6.27</td>
<td>Crime</td>
<td>2.89</td>
<td>5.41</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Loved</td>
<td>8.64</td>
<td>6.38</td>
<td>Deceit</td>
<td>2.90</td>
<td>5.68</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Love</td>
<td>8.72</td>
<td>6.44</td>
<td>Sinful</td>
<td>2.93</td>
<td>6.29</td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Happy</td>
<td>8.21</td>
<td>6.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Fame</td>
<td>7.93</td>
<td>6.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Party</td>
<td>7.86</td>
<td>6.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>Joke</td>
<td>8.10</td>
<td>6.74</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>flirt</td>
<td>7.52</td>
<td>6.91</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Positive</td>
<td>joy</td>
<td>8.60</td>
<td>7.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table A3.6
Positive and negative valenced words that were successfully normed as relating to an individual’s **physical** word.

**NOTE.** The Table also includes these words ANEW valence and arousal ratings also included.

<table>
<thead>
<tr>
<th>Category</th>
<th>Word</th>
<th>Valence</th>
<th>Arousal</th>
<th>Category</th>
<th>Word</th>
<th>Valence</th>
<th>Arousal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Positive</td>
<td>Alive</td>
<td>7.92</td>
<td>5.50</td>
<td>Cancer</td>
<td>1.50</td>
<td>6.42</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Baby</td>
<td>8.22</td>
<td>5.53</td>
<td>Rabies</td>
<td>1.77</td>
<td>6.10</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Caress</td>
<td>7.84</td>
<td>5.14</td>
<td>Ulcer</td>
<td>1.78</td>
<td>6.12</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Child</td>
<td>7.08</td>
<td>5.55</td>
<td>Hurt</td>
<td>1.90</td>
<td>5.85</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Erotic</td>
<td>7.43</td>
<td>7.24</td>
<td>Drown</td>
<td>1.92</td>
<td>6.57</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Food</td>
<td>7.65</td>
<td>5.92</td>
<td>Dead</td>
<td>1.94</td>
<td>5.73</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Heart</td>
<td>7.39</td>
<td>6.34</td>
<td>Poison</td>
<td>1.98</td>
<td>6.05</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Kiss</td>
<td>8.26</td>
<td>7.32</td>
<td>Vomit</td>
<td>2.06</td>
<td>5.75</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Life</td>
<td>7.27</td>
<td>6.02</td>
<td>Trauma</td>
<td>2.10</td>
<td>6.33</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Lust</td>
<td>7.12</td>
<td>6.88</td>
<td>Pain</td>
<td>2.13</td>
<td>6.50</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Orgasm</td>
<td>8.32</td>
<td>8.10</td>
<td>Crash</td>
<td>2.31</td>
<td>6.95</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Snow</td>
<td>7.08</td>
<td>5.75</td>
<td>Tumour</td>
<td>2.36</td>
<td>6.51</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td>Strong</td>
<td>7.11</td>
<td>5.92</td>
<td>Agony</td>
<td>2.43</td>
<td>6.06</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td></td>
<td></td>
<td></td>
<td>Ugly</td>
<td>2.43</td>
<td>5.38</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td></td>
<td></td>
<td></td>
<td>Ache</td>
<td>2.49</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td></td>
<td></td>
<td></td>
<td>Injury</td>
<td>2.49</td>
<td>5.69</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td></td>
<td></td>
<td></td>
<td>Wounds</td>
<td>2.51</td>
<td>5.82</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td></td>
<td></td>
<td></td>
<td>Burn</td>
<td>2.73</td>
<td>6.22</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td></td>
<td></td>
<td></td>
<td>Bloody</td>
<td>2.90</td>
<td>6.41</td>
<td></td>
</tr>
<tr>
<td>Physical Positive</td>
<td></td>
<td></td>
<td></td>
<td>Slap</td>
<td>2.95</td>
<td>6.46</td>
<td></td>
</tr>
</tbody>
</table>
Figure A3.1. Positive and negative ‘social’ and ‘physical’ words plotted on valence and arousal axis.
Table A3.7
Matrix of t-tests comparing mean ANEW Valence ratings for the normed positive and negative ‘social’ and physical’ words.

<table>
<thead>
<tr>
<th></th>
<th>Positive Social</th>
<th>Positive Physical</th>
<th>Negative Social</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean = 7.76</td>
<td>Mean = 7.59</td>
<td>Mean = 2.48</td>
</tr>
<tr>
<td></td>
<td>SD = 0.51</td>
<td>SD = 0.47</td>
<td>SD = 0.34</td>
</tr>
<tr>
<td>Positive Physical</td>
<td>t=1.021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean = 7.59</td>
<td>df=38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD = 0.47</td>
<td>p=.314</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Social</td>
<td>t=40.124</td>
<td>t=36.214</td>
<td></td>
</tr>
<tr>
<td>Mean = 2.48</td>
<td>df=46</td>
<td>df=32</td>
<td></td>
</tr>
<tr>
<td>SD = 0.34</td>
<td>p&lt;.001</td>
<td>p&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Negative Physical</td>
<td>t=39.996</td>
<td>t=35.441</td>
<td>t=2.146</td>
</tr>
<tr>
<td>Mean = 2.23</td>
<td>df=45</td>
<td>df=31</td>
<td>df=39</td>
</tr>
<tr>
<td>SD = 0.38</td>
<td>p&lt;.001</td>
<td>p&lt;.001</td>
<td>p=.038</td>
</tr>
</tbody>
</table>
Table A3.8
Matrix of t-tests comparing mean ANEW Arousal ratings for the normed positive and negative ‘social’ and physical’ words.

<table>
<thead>
<tr>
<th></th>
<th>Positive Social</th>
<th>Positive Physical</th>
<th>Negative Social</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean = 5.59</td>
<td>Mean = 6.24</td>
<td>Mean = 6.04</td>
</tr>
<tr>
<td></td>
<td>SD = 0.58</td>
<td>SD = 0.87</td>
<td>SD = 0.74</td>
</tr>
<tr>
<td>Positive Physical</td>
<td>t=1.311</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>df=17.302</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p=.270</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Social</td>
<td>t=0.555</td>
<td>t=0.705</td>
<td></td>
</tr>
<tr>
<td></td>
<td>df=46</td>
<td>df=32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p=.581</td>
<td>p=.486</td>
<td></td>
</tr>
<tr>
<td>Negative Physical</td>
<td>t=0.984</td>
<td>t=0.571</td>
<td>t=0.248</td>
</tr>
<tr>
<td></td>
<td>df=46</td>
<td>df=16.268</td>
<td>df=39</td>
</tr>
<tr>
<td></td>
<td>p=.330</td>
<td>p=.576</td>
<td>p=.805</td>
</tr>
</tbody>
</table>
7.4: Appendix 4:

Normed social and physical emotional word
Stimuli used in experiments 3, 4, 5 & 6
The table presents ANEW valence and arousal scores, word length and chi square probability from the word norming analyses (appendix 3) for each word stimuli. Mean valence, arousal, word length and chi-square probability for each word category are also presented.

Table A4.1
Negative and positive, social and physical normed word stimuli used in the emotional Stroop, dot probe, affective priming and biconditional discrimination experiments (i.e. experiments 3, 4, 5 & 6)

<table>
<thead>
<tr>
<th>Physical Negative</th>
<th>Physical Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Word</strong></td>
<td><strong>Length</strong></td>
</tr>
<tr>
<td>Ulcer</td>
<td>5</td>
</tr>
<tr>
<td>Crash</td>
<td>5</td>
</tr>
<tr>
<td>Bloody</td>
<td>6</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>5.3333</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social Negative</th>
<th>Social Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Word</strong></td>
<td><strong>Length</strong></td>
</tr>
<tr>
<td>Annoy</td>
<td>5</td>
</tr>
<tr>
<td>Rude</td>
<td>4</td>
</tr>
<tr>
<td>Cruel</td>
<td>5</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>4.6667</td>
</tr>
</tbody>
</table>
Note. Table A14 presents the mean valence ANEW ratings for the positive social, negative social, positive physical and negative physical word categories used in experiments 3, 4 and 5. The table also presents the t-tests comparing means between all categories. It indicates that positive categories had significantly higher valence ratings than negative categories. It also indicates that the positive social and positive physical categories did not have significantly different valence ratings and that the negative social and negative physical categories also did not have significantly different valence ratings.

Table A4.2
Matrix of t-tests comparing mean ANEW Valence ratings for the positive and negative ‘social’ and physical’ words used in experiments 3, 4 and 5.

<table>
<thead>
<tr>
<th>Positive Social</th>
<th>Positive Physical</th>
<th>Negative Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean = 8.10</td>
<td>Mean = 8.00</td>
<td>Mean = 2.40</td>
</tr>
<tr>
<td>SD = 0.53</td>
<td>SD = 0.49</td>
<td>SD = 0.39</td>
</tr>
<tr>
<td>Positive Physical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean = 8.00</td>
<td>df=4</td>
<td>df=4</td>
</tr>
<tr>
<td>SD = 0.49</td>
<td>p=.818</td>
<td>p&lt;.001</td>
</tr>
<tr>
<td>Negative Social</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean = 2.40</td>
<td>t=14.876</td>
<td>t=15.285</td>
</tr>
<tr>
<td>SD = 0.39</td>
<td>df=4</td>
<td>df=4</td>
</tr>
<tr>
<td></td>
<td>p&lt;.001</td>
<td>p&lt;.001</td>
</tr>
<tr>
<td>Negative Physical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean = 2.33</td>
<td>t=12.921</td>
<td>t=0.158</td>
</tr>
<tr>
<td>SD = 0.56</td>
<td>df=4</td>
<td>df=4</td>
</tr>
<tr>
<td></td>
<td>p&lt;.001</td>
<td>p=.862</td>
</tr>
</tbody>
</table>
Note. Table A15 presents the mean arousal ANEW ratings for the positive social, negative social, positive physical and negative physical word categories used in experiments 3, 4 and 5. The table also presents the t-tests comparing the arousal means between all categories. It indicates that the positive physical category had significantly higher arousal rating than the positive social, negative social and negative physical categories. No other category comparisons were significant indicating that the positive social, negative social and negative physical categories had comparable mean arousal ratings.

Table A4.3
Matrix of t-tests comparing mean ANEW Arousal ratings for the positive and negative ‘social’ and physical’ words used in experiments 3, 4 and 5.

<table>
<thead>
<tr>
<th></th>
<th>Positive Social</th>
<th>Positive Physical</th>
<th>Negative Social</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean = 6.29</td>
<td>Mean = 7.55</td>
<td>Mean = 6.16</td>
</tr>
<tr>
<td></td>
<td>SD = 0.49</td>
<td>SD = 0.47</td>
<td>SD = 0.42</td>
</tr>
<tr>
<td>Positive Physical</td>
<td>t=3.198</td>
<td>df=4</td>
<td>df=4</td>
</tr>
<tr>
<td></td>
<td>df=4</td>
<td>p=.033</td>
<td>p=.019</td>
</tr>
<tr>
<td>Negative Social</td>
<td>t=0.346</td>
<td>t=3.785</td>
<td></td>
</tr>
<tr>
<td></td>
<td>df=4</td>
<td>df=4</td>
<td>p=.019</td>
</tr>
<tr>
<td></td>
<td>p=.747</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Physical</td>
<td>t=0.543</td>
<td>t=2.892</td>
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</tr>
<tr>
<td></td>
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<td>df=4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p=.616</td>
<td>p=.044</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p=.389</td>
<td></td>
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</tr>
</tbody>
</table>
Table A4.4
Neutral word stimuli used in the dot probe experiment (i.e. experiments 4)
Note. The table presents ANEW valence and arousal scores for each word stimuli. Mean valence, arousal and word length for two neutral blocks are also presented.

<table>
<thead>
<tr>
<th>Word</th>
<th>Length</th>
<th>Valence</th>
<th>Arousal</th>
<th>Word</th>
<th>Length</th>
<th>Valence</th>
<th>Arousal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot</td>
<td>4</td>
<td>5.02</td>
<td>3.27</td>
<td>Door</td>
<td>4</td>
<td>5.13</td>
<td>3.80</td>
</tr>
<tr>
<td>Barrel</td>
<td>6</td>
<td>5.05</td>
<td>3.36</td>
<td>Statue</td>
<td>6</td>
<td>5.17</td>
<td>3.46</td>
</tr>
<tr>
<td>Chair</td>
<td>5</td>
<td>5.08</td>
<td>3.15</td>
<td>Board</td>
<td>5</td>
<td>4.82</td>
<td>3.36</td>
</tr>
<tr>
<td>Mean</td>
<td>5</td>
<td>5.05</td>
<td>3.26</td>
<td>Mean</td>
<td>5</td>
<td>5.04</td>
<td>3.54</td>
</tr>
</tbody>
</table>
7.5: Appendix 5:

Biconditional discrimination background scenario and participant instructions
Thank you for participating in this research

Peter is a sailor who spends six months out at sea followed by a brief spell of shore leave at a large port. On these breaks Peter and the rest of the ship's crew let loose and hit the cities bars. Peter frequently ends up stumbling drunkenly through the city's red light district looking for The Blue Moon Lodge, a reliable and friendly brothel which he has visited on shore leave many times in the past. Usually, Peter wakes in the morning with memories of a fabulous night of great sex where he had several ORGASMS.

Recently, however, Peter confides in you that on some occasions he has awoken in the morning with cuts, bruises, a BLOODY face, an empty wallet and no memory of the previous night beyond going into a room at the brothel with a couple of sex workers. You suggest to Peter that some of the sex workers, or a combination of sex workers, may be drugging him, beating him up and stealing his money. Peter therefore decides to start recording which sex workers he sees and whether he remembers having an ORGASM or waking in the morning with a BLOODY face.

As Peter's friend you decide to help him try and predict which sex workers will give him an ORGASM and which will give him a BLOODY face. For the first few occasions you can only guess about the likelihood of Peter receiving an ORGASM or a BLOODY face because you don't yet have any experience on which to base your prediction. But over time you should accumulate enough evidence on which to base sound predictions.

It is your task to enter a rating of the safety of each combination of sex worker over a number of visits to The Blue Moon Lodge. If you think the sex workers are safe and will give Peter an ORGASM then rate them low on the 9 point scale. If you think the sex workers will rob Peter and give them a BLOODY face then rate them high on the scale. If you are genuinely uncertain about the safety of the sex workers (as you will be at the outset of your task) then rate them in the middle of the scale. After you have entered your rating, click the "RESULT" button and you will be told if Peter received an ORGASM or a BLOODY face. Click the "NEXT OCCASION" button to see which sex workers Peter sees during following occasions of shore leave.

Please try to be accurate with your ratings and use the FEEDBACK you get about Peter's night at the brothel to guide your ratings. At the end of the experiment you will be asked to present your final report, in which you provide ratings of the sex workers without any feedback.