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The Influence Of Emotional Stimuli On Cognitive Performance In Relation To Delusion Intensity In Schizophrenia

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THE INFLUENCE OF EMOTIONAL STIMULI ON COGNITIVE PERFORMANCE IN RELATION TO DELUSION INTENSITY IN SCHIZOPHRENIA

by

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ABSTRACT

Previous research has suggested that there are multiple psychological processes underlying delusional thought. While it appears that cognitive biases in certain reasoning and attention processes are related to delusion-proneness, the influence of emotion on these processes is not well understood. The overall objective of this study was to investigate the effect of emotional content on performance on tasks thought to measure attentional bias, preferential recall, and probabilistic reasoning in individuals with schizophrenia and demographically matched controls. In order to account for level of delusion-proneness, participants also completed a multidimensional measure of delusional thought. It was hypothesized that individuals with schizophrenia would perform more poorly on both the emotional and neutral versions of these tasks compared to controls. It was also hypothesized that within each group, there would be a statistically significant emotion effect, indicated by a difference in performance on the emotional (compared to neutral) condition of each task. This emotion effect was expected to be larger in the schizophrenia group. Finally, it was hypothesized that the emotion effect would increase as the severity of delusional proneness increased for all participants, regardless of group. As hypothesized, the schizophrenia group performed more poorly on the tasks overall, though expected emotion effects were generally absent. There were no differences in the size of emotion effects between the groups on any of the cognitive tasks administered, and the emotion effect did not appear to increase as severity of delusion-proneness increased. Factors that may have contributed to this pattern of results are discussed. Implications of these findings on theoretical models of delusions and future directions for research in this area are also discussed.

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INTRODUCTION

"I am dead;" "aliens control my thoughts;" "the government has inserted a microchip inside my brain." These are all beliefs expressed by individuals experiencing various types of delusions, representing the "Cotard" delusion, delusions of alien control, and paranoid delusions, respectively (Coltheart, 2007; Ellett, Freeman, & Garety, 2007). Delusions, broadly defined as fixed false beliefs, are prevalent among individuals with psychotic disorders such as schizophrenia. More than 90% of schizophrenia patients experience delusions at some point during the course of their illness (Cutting, 1995). Additionally, delusions are often present in individuals with schizophrenia spectrum disorders. While the study of delusions in individuals with schizophrenia and related disorders has received the most attention in the research literature to date, the impact of delusions is certainly not limited to that population. Delusions may also be part of the symptom profile of individuals with mood disorders (e.g., bipolar disorder and major depressive disorder with psychotic features), Alzheimer's disease, and traumatic brain injury.

Defining Delusions

Though the study of delusions has spanned almost two centuries, many issues are still debated in the literature, including the precise definition of a delusion. The word 'delusion' has Latin roots, coming from the verb *ludere*, which means "to play." This particular conception of delusions refers to the observation that delusions are in many ways akin to 'tricks' being played on the mind (Butcher, Mineka, and Hooley, 2007).

When it first entered the medical literature in the early 19th century, the term 'delusion' was synonymous with the more general term "madness," and at that time referred to a general deprivation of sense or lack of brightness (Hoff, 2006). The contemporary use of the term can be traced to the work of Karl Jaspers, who is commonly credited as being the first to formally define the concept of delusions in his book *General Psychopathology* (Jaspers, 1913/1997). His definition would serve as the basis of the formal definition of delusions according to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV-TR). According to the DSM-IV-TR, a delusion is a "false belief based on incorrect inference about external reality and firmly sustained in spite of what almost everybody else believes and despite what constitutes incontrovertible and obvious proof or evidence to the contrary." Additionally, criteria entail that the belief must not be ordinarily accepted by other members of the belief holder's culture or subculture (American Psychiatric Association, 2000).

While this particular definition has its share of critics (e.g., Bell, Halligan, & Ellis, 2006; Heinimaa, 2002; Leeser & O'Donohue, 1999; Spitzer, 1990), alternative conceptualizations have not approached the definition offered by the DSM-IV-TR in terms of their acceptance or use in the field of psychiatry or psychology. Nonetheless, many of these criticisms warrant consideration. For example, Bell and colleagues make two important points regarding the definition found in the DSM-IV-TR. First, they point out that delusions might not necessarily be false beliefs *per se*, citing that a delusional belief could be a value judgment, a statement that is not amenable to hypothesis testing, or in fact turn out to be true. Secondly, they contend that the criterion that a delusion is

not ordinarily accepted by members of a culture or subculture is typically not based on empirical evidence of how widely accepted that belief may be (Bell et al., 2006).

In their critique of the epistemological criteria inherent in the definition proposed by the DSM-IV-TR, Leeser and O'Donohue suggest that the primary defining feature of delusions is not that they represent "false beliefs," but rather, that they are "uniquely unfalsifiable" beliefs (Leeser & O'Donohue, 1999). These authors posit that while the traditional definition of delusions (rooted in Jaspers' conceptualization) labels delusional beliefs as those which are believed despite evidence to the contrary, many delusional beliefs lack any clear empirical content, and thus cannot be shown to be false using any empirical evidence. According to these authors, a belief may be unfalsifiable in principle, or because the belief-holder refuses to admit to potential falsifiers; either way they argue that this particular criterion is not suitable to define many beliefs that are in fact delusional.

Recent attempts at defining delusions from interdisciplinary perspectives have taken a more integrative approach to this challenge, frequently drawing on definitions from various subfields such as psychology, psychiatry, and others. Some authors have opted to propose broader guidelines or criteria rather than narrow definitions. For example, based on common themes spanning several subfields, Gilleen and David proposed that a delusional belief is one that is held with great conviction, defies rational counter-argument, and is dismissed as false or bizarre by members of the same socio-cultural group (Gilleen & David, 2005). These authors take a twofold approach to the problem of defining delusions. While they acknowledge the difficulty in attempting to come the 'perfect' definition, they recognize the practical importance of commonly

agreed upon guidelines for the purposes of recognizing and studying clinical phenomena. These authors conclude by stating that "a more precise definition [of delusions] is probably impossible since delusions are contextually dependent, multiply determined, and multidimensional" (p. 5). Other researchers have gone beyond this view however, going so far as to state that "manuals of psychiatry or clinical psychology offer definitions of 'delusion,' but these turn out to be of little value for the scientific investigation of delusional belief" (Coltheart, 2007, p. 1043).

The Debate Continues - Categorical versus Dimensional Approaches

While the debate regarding the definition of a delusion seems far from coming to a close, another deliberation has been growing in the literature – the question of whether delusions ought to be viewed from a categorical versus a dimensional approach. This debate is not unique to the study of delusions or even psychosis; the same question has been raised in regard to symptoms of mood disorders (Akiskal & Benazzi, 2006), personality disorders (Trull, Tragesser, Solhan, & Schwartz-Mette, 2007), and other categories of psychiatric illness. The traditional approach that has been taken in these areas, including work on delusions, is the categorical approach. Within the literature on psychosis, this approach views the presence of delusions as a defining symptom of several psychotic disorders (e.g., schizophrenia). The absence of delusions, on the other hand, may preclude one from being diagnosed with certain disorders, such as delusional disorder. The pervasiveness of this view is evident not only in the DSM-IV-TR definition, but in many of the diagnostic tools typically used to diagnose and classify symptoms of psychotic disorders such as schizophrenia. Recently though, there has been

a shift in the literature towards a more dimensional approach to characterizing delusions, as well as a number of other symptoms of psychosis. This approach, while not new, has received increasing attention in the past 10 to 20 years.

According to the dimensional perspective, symptoms of psychosis lie on a continuum ranging from healthy, through eccentric, to floridly psychotic (Claridge, 1994). In terms of delusions, this view states that they are not "all-or-nothing" false beliefs; instead delusional thought is present to some degree in both healthy and psychiatric individuals. Recent work that supports this theory includes that of Peters and colleagues, who measured delusional ideation in both a healthy population and a deluded population and reported that almost 10% of the healthy population scored above the mean of the deluded comparison group on a measure of delusion-proneness (Peters, Joseph, & Garety, 1999a). This indicates not only that delusional thinking is evident in a healthy community population, but that a small percentage of this group reported experiencing higher levels than those of the deluded group.

Delusions from a Multidimensional Perspective

Expanding on the idea that delusions lie on a continuum, it has been suggested that delusions themselves can be further broken down and conceptualized as multidimensional. This idea was originally proposed by Strauss based on research that he conducted on clinical inpatients with delusions. He proposed that there are three major dimensions of delusional belief: conviction of the belief; preoccupation with the belief; and distress related to the belief (Strauss, 1969). Since that time, a considerable amount of work has been done lending support to this notion (Hanssen, Krabbendam, Vollema,

Delespaul, & Van Os, 2006; Johns & van Os, 2001; van Os, Hanssen, Bijl, & Ravelli, 2000; Verdoux & van Os, 2002). Expanding upon the work of Strauss, it has been suggested that distinct dimensions of delusions may be better predictors of the presence of psychotic illness over others. Based on their work investigating delusion proneness in psychiatric individuals and non-psychiatric members of New Religious Movements, Peters and colleagues concluded that the dimensions of distress and preoccupation differentiated the two groups, while number of delusions endorsed and conviction of delusional beliefs did not (Peters, Day, McKenna, & Orbach, 1999b). A study by Lincoln reported similar findings: distress, as well as delusional content, best discriminated non-clinical controls from schizophrenia patients (Lincoln, 2007). Both of these findings are in line with the dimensional perspective of psychosis, which contends that the experience of symptoms such as delusions is not inevitably associated with the presence of a disorder, rather, a myriad of other factors (e.g., pervasiveness of symptoms, frequency of symptoms, symptom comorbidity) ultimately play a major role in determining whether or not a given symptom is pathological (Johns & van Os, 2001). Along these lines, it has been suggested that delusional beliefs may actually exist on a continuum between typical worry, overvalued ideas, and delusions (O'Conner, 2009), and that what distinguishes 'normal' and psychotic experiences may be an individual's metacognitions (e.g., what the individual believes about a given belief).

Cognitive Approaches to Understanding Delusions

The influence of the continuum view of delusions is evident in the growing body of literature aimed at identifying the psychological mechanisms underlying individual

symptoms of psychosis. According to the continuum hypothesis, studying a pathological symptom such as delusions in *healthy* individuals can enhance the understanding of delusional thought in *psychiatric* individuals. Cognitive approaches to delusions, on the other hand, have adopted the approach of studying the cognitive processes of healthy individuals in psychiatric individuals in order to better understand how malfunctioning in normal cognitive processes can lead to pathology.

Cognitive neuropsychiatry, a major subfield in this area, seeks to gain a deeper understanding of the normal functioning of higher order aspects of cognition such as belief formation by studying people in whom such processes are abnormal (Coltheart, 2007). According to Gilleen and David (2005), the aim of the cognitive neuropsychiatric approach to delusional beliefs is to "construct theories of the normal stages involved in belief-formation, and then show how malfunctions produce characteristic psychopathology" (p. 6). This view posits that the mechanisms that lead to delusional belief are not qualitatively different in individuals with clinical delusions; rather, the same cognitive, emotional, and neurological processes are at work in these individuals, they are simply operating in a disrupted or dysfunctional way, leading to the formation and maintenance of clinical delusions. Whether addressing delusions or other psychiatric symptoms, the cognitive neuropsychiatric approach focuses on symptoms rather than diagnoses, as it is thought that the study of symptoms is more likely to elucidate functional relationships as opposed to a broad diagnostic approach (Bell et al., 2006). Other cognitive approaches have adopted a similar dimensional view.

As the name implies, most cognitive models of psychosis are anchored in some way by the primacy of cognitive processes in the formation and maintenance of psychotic

symptoms. A considerable amount of research has investigated the cognitive correlates of psychosis. Much of this work has been done with schizophrenia patients, and overall it appears that a diversity of cognitive impairments are pervasive and wide-ranging among these individuals (Heinrichs, 2005). However, recent work suggests that within this population, cognitive impairments may differ according to symptomatology. That is, individuals with primarily positive symptoms (delusions and hallucinations) may display different cognitive deficits than those with symptoms falling largely in the negative symptom cluster (Rocca et al., 2006). Coupled with work investigating delusions in other psychiatric disorders (e.g., delusional disorder), there is a growing body of literature focusing exclusively on uncovering the mechanisms responsible for the manifestation delusions. Though a full review of these theories is beyond the scope of this manuscript, it is worth noting several models that are particularly relevant to understanding the key cognitive processes underlying delusional thought.

One theme that appears in multiple theories of delusional thought is the role of abnormal or anomalous experiences. According to Maher, dysfunction at the perceptual level results in anomalous experiences for delusional individuals, who proceed to apply normal processes of reasoning and rationality in order to explain these strange experiences (Maher, 2005). Maher states that deficits in reasoning are not central to distinguishing those with delusions and those without. However, others have argued for the primacy of reasoning deficits in delusions. For instance, Gerrans has suggested that it is the failure to apply normal rules of pragmatic reasoning or rationality (e.g., What counts as good evidence? How are initial probabilities assigned to competing hypotheses?) in the context of anomalous experiences that accounts for delusional

thinking (Gerrans, 2001). An important distinction between these two ideas is the relative importance assigned to lower-level processes of perception versus higher-order processes such as reasoning. Recently, Fletcher and Frith (2009) proposed a framework for understanding delusions based on a Bayesian approach of hierarchical prediction modeling in the brain. This model narrows the gap between lower and higher-order processes by accounting for how each process influences the other in a feedback loop that leads to delusional beliefs. These authors suggest that prediction errors (a mismatch between one's expectations and one's actual experiences), have influence at the lower perceptual level, leading to anomalous experiences. Higher level processes, such as reasoning, are then fed faulty input about these experiences, leading to faulty output (i.e., conclusions) that in turn exert influence on future prediction errors at the lower level (Fletcher & Frith, 2009). This theory predicts that in time, the constant readjustments that result from this feedback loop lead one beyond faulty conclusions about isolated instances and form the basis for more global delusional beliefs.

While theories of delusions are becoming increasingly sophisticated, fundamental questions about the cognitive processes that play a central role in delusional thought remain unanswered. For example, despite the past 30 years worth of research on the subject, it does not appear that the basic question of whether individuals with delusions reason differently than those without (including both 'normal' controls and non-delusional psychiatric patients) has been definitively answered (Mujica-Parodi et al., 2000). This is not to suggest that considerable progress has not been made in the search of relevant processes to focus on. Bell et al. (2006) identified the following overarching areas of investigation as critical to the understanding of delusions: probabilistic

reasoning, attributional style, attention, and metacognition. Guided by these findings, and in light of the recent trend to focus on individual symptoms, the following review will focus on literature that specifically addressed the construct of delusions and/or distinguished participant groups based on delusional status.

Cognitive Correlates of Delusional Thought

Cognitive biases can be defined as impaired thought processes that occur as a result of one's experiences and which lead one to notice, pay attention to, or recall some types of information better than others. This in turn may bias one's interpretation of subjective experiences (Klewchuk, McCusker, Mulholland, & Shannon, 2007). Biased cognitive processes concerned with reasoning and attention have been the focus of much of the literature on the cognitive correlates of delusions. Broadly speaking, attention and delusional thought could theoretically be linked in numerous ways. For instance, it is possible that individuals with delusions selectively attend to information perceived as threatening or related in some way to a preexisting delusional belief, a theory that was first proposed by Ullmann and Krasner in 1969 (Bentall, Corcoran, Howard, Blackwood, & Kinderman, 2001). Reasoning processes have also been implicated as being directly involved in delusional thinking processes. Deficits in inductive and deductive 'formal' logical reasoning in delusional individuals appear to have been the focus of early studies in this area (Mujica-Parodi, Malaspina, & Sackeim, 2000). As this area has grown, interest in tasks thought to reflect 'everyday' reasoning ability, such as quickness of decision making under conditions of uncertainty, has increased.

Delusions and Reasoning Processes

Reasoning can be defined as "a combination of cognitive processes that allows us to draw inferences from a given set of information and reach conclusions that are not explicitly available, providing new knowledge" (Canessa et al., 2005, p. 30). One of the first researchers to formalize a theory on reasoning processes in psychotic individuals was Von Domarus, who stated that individuals with schizophrenia reason in an organized fashion but follow different rules of logic, leading to faulty conclusions (Mujica-Parodi et al., 2000). Though his original study investigating deductive logic in schizophrenia patients was conducted in 1944 (Von Domarus, 1944), few published studies appeared in this field within the next 30 years or so. However, since the 1970's, more studies have appeared which aim to investigate logic and/or reasoning abilities in psychotic individuals.

Numerous studies have reported information processing biases related to reasoning in both individuals with delusions (Garety et al., 2005; Garety, Hemsley, & Wessely, 1991; Langdon, Ward, & Colthart, 2008; Moritz & Woodward, 2005; Ross, Freeman, Dunn, & Garety, 2009; Van Dael et al., 2006) and those who are delusion-prone (Broome et al., 2007; Colbert & Peters, 2002; McKay, Langdon, & Coltheart, 2006; Linney, Peters, & Ayton, 1998; White & Mansell, 2009). Often referred to as the 'jumping-to-conclusions' (JTC) data gathering bias, this occurs when individuals utilize less information when coming to conclusions during reasoning tasks requiring judgment under uncertain conditions. Specifically, it is thought that individuals with delusions have a tendency to gather less evidence before making inferences, and it is this bias toward gathering less data that leads one to jump to conclusions while performing reasoning tasks (Garety & Freeman, 1999). In the literature, this has typically been demonstrated by

having participants perform a task which requires them to guess the probability that 'randomly' drawn colored beads come from one jar of beads over the other, based on the ratio of colored beads in each jar. Inferring that beads are being drawn from one jar as opposed to the other on the basis of very little evidence (few beads in this case) is indicative of a JTC reasoning style.

Since the first report of the JTC data gathering bias in individuals with delusions (Huq, Garety, & Hemsley, 1988), a number of studies have investigated the stability, specificity, and influence of alternate task paradigms on this finding. In order to investigate specificity, Peters et al. administered reasoning tasks to a group of psychiatric patients and then divided this group in two ways: 1) based on whether or not they were deluded; and 2) based on whether or not they were diagnosed with schizophrenia. Deluded patients were found to exhibit a JTC data-gathering bias, but no differences were found when patients were grouped by diagnosis. These findings led to the conclusion that the JTC bias appeared to be specific to delusional status (Peters, Thornton, Siksou, Linney, & Maccabe, 2007). Adding support to this point, Corcoran and colleagues investigated the JTC task in individuals with paranoid delusions (PD) across several groups including: current psychotic disorder (schizophrenia, schizoaffective disorder, and delusional disorder), current affective disorder (depression), and remitted psychotic disorder. These authors reported that all three groups demonstrated the JTC bias, regardless of diagnosis. They concluded that this particular cognitive tendency is a transdiagnosotic feature in individuals with PD (Corcoran et al., 2007).

In order to determine whether the presence of the JTC bias represents an underlying deficit in reasoning ability related to information gathering, rather than a

generalized reasoning deficit, Peters et al. (2007) administered the JTC task and two of the classic Wason reasoning tasks to individuals in the above described study. The Wason selection task is thought to measure conditional reasoning (e.g. 'if p then q'), while Wason's 2-4-6 task measures confirmation bias, or a tendency to interpret new information in a way that confirms preconceptions. These authors reported that while there were no group differences on tasks of general reasoning ability, individuals in the delusion group performed more poorly on the JTC task. They concluded that reasoning deficits in the delusion group appeared to be specific to those measured by the JTC task, rather than representing a generalized deficit in reasoning across tasks (Peters et al., 2007). The point has also been made that, although the relationship between the JTC bias and other well established cognitive impairments in schizophrenia (e.g., memory, executive functioning) is not yet fully understood, the JTC bias differs from those impairments because it appears to be specific to delusional thought (Ross et al., 2009).

Stability of the JTC bias during periods of symptom remission has also been investigated. In a longitudinal study of the JTC bias in individuals with delusions, it has been reported that this bias is present at follow-up (these individuals did not undergo specific treatment for the JTC bias). The authors of this study concluded that the JTC bias is thus a stable factor associated with delusional thinking (Peters & Garety, 2006). In a study that investigated the effect of a training session to modify the JTC bias by enhancing reasoning strategies in individuals with delusions, it was reported that participants requested more information before reaching a decision on the JTC task subsequent to training compared to the no training group (Ross et al., 2009). These authors also reported a modest effect on metacognitions about one's own delusional

thoughts in the training group compared to the no training group, though this difference was not statistically significant in their small sample. These authors concluded that a change in data gathering and reasoning techniques might mediate a change in delusional thinking, though they stressed that this conclusion was tentative (Ross et al., 2009).

While there is now strong support for the existence of the JTC data-gathering bias in individuals with delusions compared to controls (Garety & Freeman, 1999), certain factors may influence the consistency and strength associated with this finding. For instance, it was reported that while individuals with delusional disorder did show a JTC reasoning style when compared to controls, when performing on a task that added consequences to their decisions, this difference disappeared (Fear & Healy, 1997). Other researchers have reported that increasing memory demands of the task results in larger differences between deluded individuals and controls (Menon, Pomarol-Clotet, McKenna, & McCarthy, 2006). Task difficulty may also influence performance on this task, as some studies have found that altering the ratio of beads from 85:15 to 60:40 improves performance in individuals with delusions (presumably because participants become more cautious in their estimations), while others have failed to replicate this finding (Ziegler et al., 2008).

One important factor that has only recently received attention in the literature is the emotional salience of the task. While the traditional JTC beads task is considered emotionally neutral, versions have been developed that introduce an emotional component to the task. These paradigms may ask participants to make judgments under uncertainty on tasks where they are read positive and negative statements, and must

decide which list (containing different ratios of positive and negative statements) these statements originated from (Dudley, John, Young, & Over, 1997b).

In what appears to be the first study to investigate this relationship, Dudley and colleagues (1997b) found support for the hypothesis that emotional salience impacts the JTC bias. These authors reported a reduction in the amount of evidence participants requested before coming to a conclusion while performing an emotional JTC task. However, this finding was not exclusive to their group with delusions; it was also evident in individuals with other psychiatric disorders, as well as controls. In a study by Warman and colleagues, three groups (individuals with delusions, delusion-prone individuals, and controls) were compared on their performance on two tasks: a neutral and a highly self-referent (emotional) JTC task. The findings from this study indicated that those with clinical delusions gathered significantly less information than both comparison groups on both of the tasks. They also made less accurate decisions than both groups but were more confident in their decisions. On both of those measures, the delusion-prone group did not differ from the control group. However, both the deluded and delusion-prone groups reported higher self-confidence on the emotional task compared to their own performance on the neutral version of the same task (control participants did not differ by task), suggesting that high self-reference impacted information processing in these groups (Warman, Lysaker, Martin, Davis, & Haudenschield, 2007).

An alternate method of investigating the impact of emotion on the JTC bias by inducing state anxiety has been reported in a small number of recent studies. It appears that two of these investigations included individuals with delusions. Ellett et al. (2007) exposed individuals with persecutory delusions to either an anxiety invoking situation

(exposure to a busy urban environment), or a mindfulness task designed to reduce anxiety. These authors reported that subsequent to exposure, participants in the anxiety inducing condition displayed a more pronounced JTC bias compared to the anxiety reducing condition. In a study investigating the JTC bias in individuals with delusions and healthy controls, anxiety was induced via a mental imagery paradigm. Results from this investigation indicated that there was no difference between the groups on the JTC task, however authors pointed out that the anxiety induction technique did not appear to be successful in the delusion group, and both groups displayed unusually high rates of the JTC bias (So, Freeman, & Garety, 2008).

In a study investigating treatment for delusions with antipsychotic medication, the JTC task was administered pre- and post-treatment in order to explore whether task performance mediated or moderated changes in symptom levels between the testing periods. Both a neutral and emotional version of the task was administered to individuals with psychosis before and after treatment with antipsychotic medication. Results indicated that, post-treatment, participants required more information (considered an improvement) before making a decision on the emotional JTC task (but not the neutral version). It was also reported that baseline performance on the emotional JTC task helped predict which patients showed improvement in their positive symptoms post-treatment. These authors found that while JTC performance did not mediate the effects of treatment on symptomatology, it may have moderated that relationship (Menon, Mizrahi, & Kapur, 2008).

Research investigating other reasoning biases has further elucidated the nature of reasoning processes in individuals with delusions, therefore a brief review of this work

follows. Attributional reasoning refers to a tendency to attribute ambiguous events to an internal cause (oneself) versus some external cause, such as another person (Bentall et al., 2001). The first study to investigate this bias in individuals with schizophrenia (specifically those with persecutory delusions) reported that these individuals tend to excessively attribute positive events to internal causes and negative events to external causes as compared to individuals with depression and normal control participants (Kaney & Bentall, 1989). The finding that individuals with persecutory delusions display this characteristic bias in attributional styles (often referred to as an exaggerated externalizing bias, or EB) has been replicated (Bentall & Kaney, 1996; Bentall, Kaney, & Dewey, 1991; Bentall, Kinderman, & Kaney, 1994; Candido & Romney, 1990; Kinderman & Bentall, 1997; Kinderman, Prince, Waller, & Peters, 2003). Other researchers, however, have failed to find an EB in individuals with persecutory delusions (Martin & Penn, 2002; McKay, Langdon, & Coltheart, 2005), or in some cases have reported partial support for an abnormal attributional bias that is not specific to persecutory delusions (Humphreys & Barrowclough, 2006). Though the theory that attributional reasoning biases contribute to delusional thought has amassed considerable support, more work is clearly needed to determine whether this reasoning bias generalizes to all subtypes of delusional thought or is specific to persecutory delusions.

Another area of interest in the literature on reasoning and delusions is the investigation of the relationship between delusions and deficits in processing evidence. The ability to correctly process confirmatory evidence to support a belief, coupled with the ability to integrate evidence that disconfirms an erroneous thought, appears to be important to the overall question of how normal beliefs are formed and maintained

(Garety, Kuipers, Fowler, Freeman, & Bebbington, 2001). A deficit in the ability to integrate disconfirmatory evidence into previously held beliefs is known as a bias against disconfirmatory evidence (BADE), and it has been suggested that individuals with delusions routinely disregard evidence that disconfirms their delusional thought in order for delusional beliefs to be maintained (Freeman, Garety, Kuipers, Fowler, & Bebbington, 2002). The presence of a BADE has been reported in schizophrenia patients with delusions (Woodward, Moritz, Cuttler, & Whitman, 2006), and individuals who are delusion-prone (Woodward, Buchy, Moritz, & Liotti, 2007). Addiitonally, it has been reported that a BADE does not appear to be due to more generalized reasoning or cognitive (e.g., attention) deficits (Moritz & Woodward, 2006; Woodward et al., 2006). Taken together, research investigating reasoning biases, including JTC, an exaggerated externalizing bias, and a BADE highlight the importance of understanding reasoning processes in individuals with delusions.

Delusions and Attentional Bias

The study of general attention deficits in individuals with schizophrenia encompasses a vast amount of research spanning decades. Within the literature on delusions and other positive symptoms of psychosis (e.g., hallucinations), the study of attentional biases has become a focus only recently. Attentional bias has been investigated both as a primary process of interest, and as a lower level process contributing to higher level functions, such as reasoning (Barch & Carter, 1998). In a recent study evaluating performance on numerous neuropsychological domains (including attention, memory, perceptual-motor speed and other executive processes) in

individuals with schizophrenia, only the attentional deficit domain was correlated with positive symptoms (Rocca et al., 2006). However, it should be noted that these authors did not assess reasoning ability.

In broad terms, attentional bias refers to a tendency to devote more or less attentional resources toward particular stimuli due to the relative importance of those stimuli. According to Yantis, stimuli that gets selected by the attentional system at any given moment is determined by 1) the properties of the scene; and 2) the expectations, beliefs, and goals of the observer (Yantis, 1996). Attentional bias may result from any number of deficits or differences in attention capacity, for example, increased time taken to disengage from a particular stimuli perceived as threatening is a type of attentional bias (Fox, Russo, Bowles, & Dutton, 2001).

Attentional bias has been widely studied in both mood (Leppanen, 2006) and anxiety disorders (Bishop, 2007). Recently however, it has been argued that the study of attentional biases is critical in individuals with schizophrenia based on the interactive effects of attentional biases coupled with other deficits common in psychotic individuals, such as a tendency to gather little information before reaching strong conclusions (Moritz & Laudan, 2007). According to these authors (2007), the combination of both scarce *and* affectively biased data selection of available information may distort inner representations, prompting the formation of false beliefs, thus contributing to delusion formation and maintenance.

In individuals with delusions, attentional biases may be present across numerous task modalities, including visual and auditory domains. Various task paradigms that have been used to measure these abilities include vigilance tasks (e.g., visual scanning of

faces), selective attention tasks (e.g., variants of the Stroop task), as well as attention/working memory tasks (e.g., word list tasks). Work in this area has attempted to analyze attentional differences both in individuals with clinical delusions and those identified as delusion-prone.

In a several studies of individuals reporting high levels of delusion-proneness, biased attention toward angry and threatening faces has been reported (Arguedas, Green, Langdon, & Coltheart, 2006; Green, Williams, & Davidson, 2003a; Green, Williams, & Davidson, 2001; Laroi, D'Argembeau, & Van der Linden, 2006). Some of these studies also investigated recognition memory for affective faces as well. While Green and colleagues (2003a) reported impaired affect recognition of fear faces in delusion-prone individuals, Laroi et al. (2006) reported enhanced memory (indicative of an attentional bias) toward angry faces in their sample of delusion-prone individuals. Attentional bias toward threatening faces has also been investigated in individuals with delusions. In a study comparing deluded and non-deluded schizophrenia patients, it was reported that visual scanning patterns of deluded patients reflected an attentional bias away from salient features of faces signifying direct threat (anger), and more general avoidance of faces signifying indirect threat (fear) expressions (Green, Williams, & Davidson, 2003b).

Another paradigm for investigating visual attentive bias in individuals with delusions is the inhibition of return (IOR) paradigm developed by Mortiz and Laudan (2007). These authors had two groups of individuals with schizophrenia (divided by the presence or absence of paranoid delusions) complete a task requiring them to view cue pictures, some of which were paranoia-relevant, on either side of the computer screen. Following the picture display, individuals saw a target appear at the same or opposite

location, and had to indicate where the target was. Participants responded faster to targets following paranoia scenes, regardless of delusional status. These authors concluded that the attentional bias toward paranoia cues displayed by individuals with schizophrenia facilitated the processing of subsequent information processing (Moritz & Laudan, 2007).

It has been suggested that if individuals with delusions show attentional biases toward particular (e.g. threat-related) stimuli, they might tend to preferentially recall this information as well (Bentall, Kaney, & Jones-Bowen, 1995). These authors tested this theory across three groups: individuals with persecutory delusions, individuals with depression, and controls, all of whom performed a word recall task. Word lists contained threat-related, depression-related, and emotionally neutral words, which participants were instructed to recall immediately following presentation. These authors reported that patients with delusions recalled fewer words overall compared to normal participants, and showed a bias toward recall of threat words (a bias not displayed by the depressed group) and depression words (as did depressed patients). The delusion group also showed a unique tendency to repeat threat-related words during recall (Bentall et al., 1995). These results were somewhat consistent with a previous study that reported increased recall of threatening propositions from stories that contained threatening and non-threatening themes by deluded patients compared to control participants. However, in this study, there was no evidence that the deluded group had an abnormal tendency to recall threatening stories as a whole compared to non-threatening stories (Kaney, Wolfenden, Dewey, & Bentall, 1992).

An alternative way to investigate attentional biases is by using tasks during which inhibition of automatic or prepotent attentional features is required for efficient task

performance. The emotional Stroop task is one such task. This task is regarded as the principle research tool for investigating attentional biases (Wells & Matthews, 1996). The emotional Stroop task is a variant of the more well-known classic Stroop paradigm, during which color words are presented in congruent (the color "red" in red ink) or incongruent (the color "red" in green ink) ink, and participants must name the ink color of the word. The phenomenon whereby it takes longer for healthy participants to name the ink color in the incongruent condition has been dubbed the "Stroop effect," and is thought to be due to the cognitive interference created by suppressing one's habitual response to read words in favor of the non-habitual response of naming the ink color (MacLeod, 1991).

The original version of the Stroop task places demands on selective attention, as well as other executive functioning processes such as conflict response monitoring and response inhibition (Gruber, Rogowska, Holcomb, Soraci, & Yurgelun-Todd, 2002). The emotional Stroop task is based on the same general premise, and the administration of the two variants is practically identical. However, instead of color words, the emotional Stroop task utilizes emotionally salient words (e.g. positive or negatively valenced words) and neutral words in order to assess the extent to which emotional stimuli captures attentional resources (Williams, Mathews, & MacLeod, 1996). The task is thought to measure selective attention to emotionally relevant stimuli by contrasting the extra time it takes to name the ink color during trials involving emotionally salient words compared to trials of neutral words (Thomas, Johnstone, & Gonsalvez, 2007). Notably different from the classic Stroop task, this task places less demands on conflict response monitoring, as it is more difficult to name the ink color of a conflicting color word

(classic task) as opposed to a word unrelated to color. Common to both paradigms, however, one must still suppress the habitual reading response.

Emotional Stroop interference has been found across a wide range of different clinical conditions (Williams et al., 1996). In the first study utilizing this task paradigm with individuals with persecutory delusions, four 'word' lists were used: meaningless strings of "O's, neutral words, negative words, and paranoia words. The authors of this study reported that individuals with paranoid delusions displayed increased reaction time (indicating increased interference) when processing paranoia words (Bentall & Kaney, 1989). Similar results were reported in a subsequent study investigating emotional Stroop interference in individuals with persecutory delusions, individuals with depression, and healthy controls. Individuals with paranoid delusions were found to take longer to color name words with either a positive or negative valence compared to controls (Kinderman, 1994). In a study of individuals with delusional disorder, it was reported that participants demonstrated greater interference for threatening words compared to controls (Fear, Sharpy, & Healy, 1996b). Interestingly, these authors found that individuals within the delusion group with non-persecutory delusions also showed increased interference for other types of emotionally salient words (anxiety and sadness words) compared to controls.

In a variation of this classic emotional Stroop paradigm, the emotional Stroop task was used as an experimental manipulation of attentional bias to different sources of threat in individuals with persecutory delusions, those with depression, and a healthy control group. All groups completed a measure of self-concept (containing 30 negative and 30 positive words rating self-concept) before and after the Stroop task. Before the Stroop

task, there were no statistically significant differences on the self-concept measure between the groups, however, following administration of the emotional Stroop task, individuals in the deluded group showed a statistically significant discrepancy on self-concept ratings (self-concept was rated more negatively) compared to the two other groups (Kinderman et al., 2003). These findings suggest that the activation of attentional biases present in individuals with persecutory delusions influences other reasoning biases.

While there is a small body of research investigating emotional Stroop performance in individuals with persecutory delusions, there appears to be less work investigating individuals with other types of delusions. In a case study of an individual with delusional beliefs that she had died (Cotard delusion) and that members of her family had been replaced (Capgras delusion), it was reported that on an initial emotional Stroop task, she displayed an attentional bias toward words related to her delusional beliefs. Once those beliefs remitted, she no longer displayed any difference between neutral words and words relevant to her previously held delusional beliefs (Leafhead, 1996). Based on this study, the emotional Stroop task appears to be similarly useful for investigating attentional bias in individuals with other subtypes of delusions beyond persecutory type.

Taken together, the research on attention biases in delusion-prone and delusional individuals supports the theory of an attentional bias, particularly in the presence of stimuli that is salient in some way to these individuals. However, the pattern of such a bias (e.g. whether attention is directed toward or away from salient stimuli) is not clear, even in cases when tasks may be very similar (e.g. in tasks assessing attention toward

threatening faces). Furthermore, the impact of attentional bias in individuals with delusions remains unclear. On particular laboratory-based tasks, an attentional bias may be helpful, such as in the case of increased task efficiency following paranoia cues reported by Mortiz and Laudan (2007); conversely, an attentional bias toward threatening stimuli could impair performance when preferential attention to such stimuli is not relevant to the task at hand, such as during performance on an emotional Stroop task.

While attentional bias has become an important area of research into cognitive processes in individuals with delusions (Rossell, Shapleske, & David, 1998), there appears to be a relative paucity of work investigating attentional bias in individuals across a range of delusions. As evidenced from the above review, there is a growing body of work focusing on persecutory delusions and the construct of paranoia, which makes sense considering the prevalence of this subtype of delusional beliefs. However, the generalizability of these findings to other types of delusions is somewhat limited. Additionally, while there is a significant body of research investigating a wide range of attentional processes in individuals with schizophrenia, the application of these findings towards an understanding of the theoretical mechanisms underlying delusional thought is limited. Despite these limitations, findings concerning attentional biases in individuals with delusions do point to a number of specific areas of inquiry for further research. One of these areas is the importance of emotion. Inherent to the study of attentional bias is the influence of the saliency of the material attended to (or ignored). It has been suggested that emotion and cognition appear to be necessary to both information processing and the implementation of resultant behaviors in those behaviors essential for attention (Wolfe & Bell, 2007).

In reviewing the literature investigating the cognitive reasoning biases related to delusional beliefs, several trends are apparent. It has become increasingly accepted to investigate cognitive processes related to delusions both in clinical populations and in delusion-prone non-psychiatric individuals. Increased attention on specific cognitive processes such as reasoning and attention biases, as opposed to more generalized cognitive deficits, is also evident. Additionally, the role of other psychological processes is increasingly being recognized, especially the possible influence of affective processes as they relate to cognitive functions such as reasoning and attention.

The Role of Emotion in Cognitive Models of Delusional Thought

While cognitive dysfunction is clearly a cardinal feature of schizophrenia, and is evidently related to delusion-proneness as well, some researchers have argued that the role of emotional dysfunction in symptom formation and maintenance may be just as important (Aleman & Kahn, 2005). According to Garety and colleagues (2007), emotional processes appear to have a distinct role in the formation and maintenance of delusions, however, this role has received considerably less attention than that of the cognitive correlates. Their model, as well as other cognitive models of psychosis, has increasingly pointed to the importance of emotions as directly contributing to the development of delusions, the content and themes of delusions, and the treatment of delusions. While the line of research recognizing the potential contributory role of emotion in the delusional process is quite new, there are already competing models aiming to explain the mechanisms by which cognitive and emotional factors contribute to delusional thought.

The cognitive model of psychosis developed by Garety and colleagues is notable for stressing a multifactorial account of the formation and maintenance of delusions (Garety et al., 2001). The framework presented by these authors incorporates the cognitive, emotional, social, and neurobiological correlates of delusions, with an emphasis on understanding how these factors interact in a way that results in pathological delusional thought. Influenced by the dimensional approach to delusions, these authors propose that the presence of psychotic experiences does not independently predict transition to psychosis, instead, there are specific cognitive and emotional factors working in combination that encourage the emergence of a clinical disorder (Garety et al., 2007). In their recent review covering cognitive models of psychosis (which encompass both delusions and hallucinations), these authors present support for the following hypotheses: 1) symptoms of psychosis lie on a continuum of normal functioning; 2) cognitive reasoning biases contribute to the occurrence of delusions; 3) these biases may represent risk factors for the transition from subclinical to clinical symptoms; 4) emotional processes contribute to the occurrence and persistence of psychotic features; and 5) social adversity and trauma are associated with psychosis (Garety et al., 2007).

Garety et al.'s model is primarily concerned with delusions commonly seen in individuals with psychotic disorders, including but not limited to persecutory delusions, grandiose delusions, delusions of reference, and other less common subtypes (e.g. jealousy delusions). These authors suggest that the most common route to positive symptoms such as delusions is through cognitive *and* affective changes that are triggered by external events. The interpretation of these events is influenced by disruptions in

cognitive processes of attention and reasoning, which are in turn influenced by emotional changes feeding back into the moment-by-moment processing of these experiences (Garety, Kuipers, Fowler, Freeman, & Bebbington, 2001). For example, imagine that an individual sees a car parked outside his house. If this individual displays a cognitive reasoning bias like the JTC bias, he may interpret this to mean that someone in the car is watching him. The emotional implications of this interpretation may include feelings of fear and anxiety. These affective processes then feed back into further cognitive appraisals about the situation, potentially leading the individual to additional conclusions, for example, he may think that the intent of the individual watching him is to harm him in some way. This simple example only addresses one reasoning bias that may be present and ignores the role of other important factors thought to contribute to delusions, however, numerous reasoning biases (e.g. externalizing attributional bias, disconfirmation bias) and other cognitive deficits (e.g. attention deficits) may be present in reality.

In the model of delusions proposed by Garety and colleagues, these authors argue that emotion plays a direct role in the development of delusions via the influence of affective processes on cognitive appraisals. Alternatively, it has been suggested that delusions actually serve a defensive role against the experience of negative emotions. The defense model of delusions, as it is known, states that when there is the potential for negative self-beliefs to become activated, delusions defend against this by serving as an external source with which to attribute those negative appraisals (Bentall et al., 1991; Bentall et al., 1994). This model was developed primarily to account for persecutory delusions in paranoid individuals. Early conceptions of this model suggested that the

main cognitive reasoning process at the heart of this theory is attributional style. For example, if an individual loses her job there is the potential that she may attribute this event to negative characteristics about herself (an internal attribution). According to the defense model however, she may instead conclude that her boss is out to get her (an external attribution), thus defending against dealing with negative attributions directed at herself. Recently, the authors of this model conducted a large scale investigation of cognitive and emotional processes in individuals with paranoid delusions with the aim of distinguishing which variables best predicted delusions. These authors reported that paranoid delusions were associated with a combination of pessimistic thinking style, including pessimistic explanatory style and negative emotion, and impaired cognitive performance, including the JTC bias and impaired ability to reason about the mental states of others. Interestingly, these authors also pointed out that emotion-related processes were more closely linked with paranoid delusions than cognitive performance in their investigation (Bentall et al., 2009).

Although they present different mechanisms by which emotion influences delusions, both the direct and defense models address the importance of the role of affect on cognitive processes. These models also share considerable overlap in terms of the theoretical underpinning cited to support them, as well as other cognitive models not mentioned here. One influential theory that has shaped both models is the idea that psychotic and emotional disorders are not discrete clusters of disorders; rather, it has been argued that disorders of emotion and psychotic disorders actually share considerable overlap. According to Lake's recent review of the area, this argument can be traced back to the work of Emil Kraepelin, who initially differentiated 'dementia praecox' (later

renamed schizophrenia) from ‘manic-depressive insanity’ (Lake, 2007). However, this sharp distinction, which is reflected in ‘gold standard’ diagnostic instruments, such as the DSM-IV-TR (2000), has been questioned by Lake and others (Craddock & Owen, 2005; Lake, 2007; Marneros, 2006). This question has been echoed in the body of literature that has focused on the relationship between emotional disturbance and the positive symptoms of psychosis, including delusions. It has been argued that a lack of empirical evidence to support a sharp distinction between these constructs, coupled with data supporting the relationship between emotion and positive symptoms of psychosis suggests that disorders of emotion and psychosis should no longer be theoretically separated (Freeman & Garety, 2003).

Another theme that appears in the delusion literature that has influenced theoretical perspectives suggesting the importance of emotion in delusional thought processes is the finding that the content of delusions frequently reflects the content of an individual’s affective state (Freeman & Garety, 2003). For instance, persecutory delusions - which often contain themes of being followed or threatened - are thought to be linked to anxiety (Freeman, 2007). All of the major emotions, including anxiety, depression, anger, happiness, disgust, and jealousy, correspond to different subtypes of delusions. For instance, happiness is thought to relate to grandiose delusions, while depression is thought to relate to guilt delusions (Chadwick, Trower, Juusti-Butler, & Maguire, 2005; Freeman & Garety, 2003). Of course, there are subtypes of delusions (e.g. religious delusions) that do not correspond directly to any one emotion, which may indicate that not all cases of delusion relate directly to emotional concern (Freeman & Garety, 2003). Furthermore, while most delusions present in individuals experiencing

mood disorders with psychotic features are found to be mood-congruent (77.4%), a significant proportion of individuals report experiencing mood-incongruent or mixed delusions (Fennig, Bromet, Karant, Ram, & Jandorf, 1996). Thus, it appears that while all major emotions appear to be reflected in some delusion subtype, not all subtypes necessarily reflect emotions, at least not in a clear manner. Clearly, more work is needed to establish the role of emotion in delusion formation beyond the observed relationship between delusion content and affective state.

Finally, recent work has investigated the relationship between emotional states and dimensions of delusions, although most of this work is too recent to have made a significant impact on cognitive models of delusions per se. Smith and colleagues examined the role of current levels of depression, self-esteem, and negative evaluative beliefs in relation to both delusion subtypes and dimensions of delusional belief. Subtypes of interest included both grandiose and persecutory delusions, and within each type, dimensions of pre-occupation, conviction, and distress were examined. These authors reported that individuals with higher levels of depression, lower self-esteem, and more negative evaluations reported persecutory delusions of greater severity and were more preoccupied and distressed by them. Additionally, it was reported that the severity of grandiose delusions was associated with higher self-esteem and inversely related to depression and negative evaluations about the self (Smith et al., 2006). This work provides further support for theoretical models suggesting a contributory role (i.e. emotion is neither necessary nor sufficient) of emotions in delusional thought (Freeman & Garety, 2003). Additionally, this work suggests that emotion may differentially influence discrete dimensions of delusional thought, namely severity, preoccupation, and

distress, though more research is needed in order to clarify this putative relationship. Taken together with theoretical models suggesting that the influence of emotion on delusional thought may depend on a number of factors, including delusion subtype, a multifaceted model of the relationship between emotions and delusions is emerging. However, this model will likely remain incomplete without taking into account how emotions may influence cognitive processes thought to contribute to delusion formation and maintenance, particularly attention and reasoning.

Emotional Dysfunction in Schizophrenia and Delusions

Certainly, the suggestion that dysfunctional emotional processes are present in psychotic individuals is not new. It has previously been established that emotional deficits are a core feature of schizophrenia. Three major deficit areas have been identified: emotional perception, emotional experience, and emotional expression (Aleman & Kahn, 2005). Within each of these domains, numerous deficits and differences have been reported, including impaired emotional facial recognition (Namiki et al., 2007) and deficits in emotional expression (Burbridge & Barch, 2007). In terms of psychotic symptoms such as delusions, the literature suggests that an increase in emotional experience coupled with a diminished ability in emotion perception is a common pattern in these individuals (Aleman & Kahn, 2005).

While the body of literature investigating emotion processing in psychotic individuals is too extensive to cover here, many authors in this field have adopted the strategy of investigating the relationship of emotion processing deficits with other psychological processes of interest (e.g. Pinkham & Penn, 2006). For instance, these

authors have proposed the term ‘social cognition’ to encompass other aspects of cognition that are not typically assessed using traditional neurocognitive tasks but that are potentially important to emotional and social dysfunction seen in individuals with schizophrenia (Pinkham, Penn, Perkins, & Lieberman, 2003). Research on functional outcome in schizophrenia has also encouraged the trend to increase attention towards the influence of emotional processes, as it has been reported that emotion deficits may be better predictors of social dysfunction than cognitive deficits (Aleman & David, 2006).

Though core symptoms of psychosis, such as cognitive and social dysfunction, are increasingly being related to deficits in emotional processing (Kuipers et al., 2006), many questions remain unanswered to date. For instance, the nature of the relationship between emotional deficits and other symptoms is still not clear. In regards to delusions, it has been pointed out by Garety et al. (2005) that “at present, it is an open question whether the contributions of reasoning and emotional processes to delusional severity are independent or act in combination (p. 374).”Also, questions of causality abound. More than half a century ago, Bleuler argued that in psychotic individuals, weakened reasoning processes allowed emotions to take hold of the individual, thus manifesting themselves in delusions (Freeman & Garety, 2003). Alternatively, it is possible that there is a core deficit that leads to impaired reasoning, dysfunctional emotional responses, and other cognitive and emotional deficits associated with psychosis.

If there are multiple pathways to delusional thought, as suggested by a number of researchers, it is critical not only to identify each pathway, but to understand how these pathways interact. The confluence of cognition and emotion may arguably be the most important pathway leading to delusional formation and maintenance. It has been

previously suggested (in relation to the study of psychotic symptoms) that "emotion and cognition are best thought of as separate but interacting mental functions mediated by separate but interacting brain systems" (Aleman & Kahn, 2005, p. 284). According to this perspective, understanding the role of just one aspect is not just missing half the picture, it is more like trying to solve a puzzle without all of the pieces.

Understanding the cognitive and emotional correlates of delusions has important implications for the treatment for individuals with schizophrenia and other disorders characterized by delusions. Though antipsychotic medication is currently considered a first-line treatment for symptoms of psychosis, researchers have suggested that cognitive behavioral therapy (CBT) may be an important treatment component to be used in conjunction with medication (van der Gaag, 2006). These authors point out that while antipsychotic medications clearly improve positive symptoms such as delusions, delusions do not seem to be eliminated by medication alone. One influential theory in this area suggests that antipsychotic medications, specifically dopamine antagonists, "dampen the salience" of abnormal experiences, but do not necessarily target other dimensions of delusional thought that serve to maintain delusional beliefs. In other words, it has been proposed that antipsychotic medication does not fundamentally change thoughts or ideas; instead, these ideas lose their significance, thus dimensions such as the preoccupation and distress associated with the beliefs are diminished, while conviction may remain relatively unchanged (Kapur, 2003). CBT, on the other hand, has shown promise for improving (by lowering) conviction in individuals with delusions. Past research has reported that CBT may be effective at reducing delusional conviction in approximately

50% of treated cases (Garety et al., 1997; Jakes, Rhodes, & Turner, 1999; Tarrier et al., 1998).

Work investigating the relationship between psychological processes and dimensions of delusions has found evidence that cognitive and emotional processes may both relate to dimensions of delusions. For instance, one study reported that belief flexibility (a cognitive process) and levels of anxiety (emotion) both contributed to overall delusion conviction (Garety et al., 2005). While efforts to modify and enhance CBT to better target the rather unique set of psychological processes contributing to delusions is already underway, more work is needed in this area. Specifically, more work aimed at elucidating how the cognitive and emotional correlates of delusional thought interact is critical in order to clarify the potential pathways to changing these thoughts in therapy.

Other research has focused on understanding dimensions of delusions because of potential power for predicting long-term outcome in individuals with schizophrenia. A recent study reported that poor (compared to good) outcome patients had delusions that were characterized by greater conviction, extension, disorganization, bizzareness, and pressure (Opjordsmoen & Retterstol, 2007). Although these authors suggested that dimensions of delusional thought may have predictive power for long-term outcome, they cautioned that this finding required replication. While much of the research in this area is preliminary, two important points have emerged. Taken together, these findings suggest that it is critical to understand the cognitive and emotional correlates of delusional thought because of the potential value of dimensions of delusions in predicting treatment outcome. Secondly, it appears that CBT, which was once not thought of as a viable

treatment for psychotic disorders, is now being recognized for its potential value in treating symptoms such as delusions (Zimmermann, Favrod, Trieu, & Pomini, 2005).

Current Aims and Hypotheses

Previous research has established that numerous cognitive and emotional factors appear to contribute to delusions. The theory that these factors may somehow exert their impact in combination to form and maintain delusional thought is also gaining acceptance. Though a handful of recent studies have begun investigating this link, this line of research appears to be in its infancy. More work is needed which aims to clarify the nature of the relationship among cognitive processes, emotions, and delusions.

The current study sought to investigate how emotional content influences cognitive biases that have previously been shown to be present in individuals with delusions. Three tasks assessing reasoning and attention biases were selected based on the available literature in each respective area. In order to address the influence of emotion processing on task performance, emotionally salient stimuli were incorporated into these cognitive tasks, creating two conditions (emotional and neutral) of each task. This method allowed for task performance to be explored using both raw values of selected indices of performance (e.g., reaction time in the emotional Stroop task) and an additional measure of the 'emotion effect.' This term refers to the discrepancy between performance in the emotional and neutral condition in matched set of tasks. Though each task possessed a different metric of general performance, for instance, total number of words recalled on the word recall task versus number of trials to decision on the jumping

to conclusions task, the emotion effect consistently refers to the difference between the emotional and neutral conditions of each respective set of tasks.

While there are various methods of investigating the influence of emotion on cognitive performance, including measuring pre-existing emotional state, or by inducing mood states unrelated to task stimuli, the current study manipulated the emotional salience of the actual task itself. It was thought that this approach would most accurately address the main research question of interest, that is, how are cognitive reasoning and attention processes influenced by the concurrent processing of emotional salience specific to the task or problem at hand, and does this relationship differ in individuals with delusions? In order to address the latter portion of that question, two groups were be investigated – individuals with a current diagnosis of schizophrenia and community controls.

In reviewing the literature on delusions and psychosis, it is apparent that delusions are most commonly studied among individuals with schizophrenia. Much of the past work investigating the psychological factors of delusions have lumped individuals with delusions together with those who do not have delusions. This method could potentially mask differences that exist between the two groups. While the traditional technique of administering a battery of neurocognitive tasks to a heterogeneous group of individuals with schizophrenia has contributed greatly to our understanding of the disorder (Heinrichs, 2005), there are some drawbacks to using this technique to address certain questions. One potential problem is that the heterogeneity of symptoms commonly observed in schizophrenia samples may introduce unintended variance when analyzing performance on cognitive and/or emotional processing tasks. Some authors have

suggested that future research investigating the cognitive and emotional interactions underlying single symptoms of the disorder is needed in order to achieve a deeper understanding of schizophrenia (Aleman & David, 2006). To that end, the current study administered a multidimensional measure of delusional thought in order to account for dimensionality of delusion-proneness in our analysis of the data.

By administering an emotional and neutral version of each task, in addition to the multidimensional delusion measure, two indices of task performance could be compared among the two groups as well as across the continuum of delusion-proneness. Consistent with an overall cognitive deficit as suggested in the literature, it was hypothesized that individuals with schizophrenia would perform more poorly on both the emotional and neutral versions of these tasks, as compared to performance of controls. It was further hypothesized that within each group, there would be a statistically significant emotion effect, indicated by a difference in performance on the emotional (compared to neutral) version of each task. In addition, it was hypothesized that this predicted emotion effect would be larger in the schizophrenia group compared to the control group. Finally, it was hypothesized that the emotion effect would increase as the severity of delusional proneness increased for all participants, regardless of group.

In addition to these hypotheses, exploratory analyses were also conducted in order to examine the effects of other task components not directly addressed in our primary hypotheses. Tasks were analyzed with respect to stimulus valence (positive or negative) to examine whether participant's performance was differentially affected by emotion type. Additional analyses were also conducted in order to examine the effect of the dimensions of delusion preoccupation, conviction, and distress on performance.

METHODS

Participants

Power Analysis

In order to obtain an estimate of optimal sample size, a power analysis was conducted prior to data collection. A small number of previous studies investigating reasoning biases in deluded individuals with schizophrenia compared to non-psychiatric controls using the same JTC task variants as the proposed study were identified (Dudley, John, Young, & Over, 1997a; Dudley et al., 1997b; Menon et al., 2006). Effect sizes reported in these studies ranged between small (Cohen's $d = 0.34$) and large (Cohen's $d = 1.43$), based on Cohen's guidelines (J. Cohen, 1988). The average combined effect size from these studies (Cohen's $d = 0.88$) falls in the large range. Few studies have investigated emotional Stroop performance specifically in individuals with delusions compared to controls. In one study that administered an emotional Stroop task (including neutral, positive, and negative words) to schizophrenia patients with persecutory delusions and healthy controls, a medium effect size (Cohen's $d = 0.72$) was calculated using Stroop interference scores (time to complete emotional word trials minus time to complete neutral trials; Kinderman, 1994). Finally, in a previous study investigating attentional bias using a word recall task in individuals with delusions (persecutory) compared to healthy controls (Bentall et al., 1995), the effect size for the difference between recall of emotion (threat or depression-related) and non-emotional words was calculated and fell in the large range (Cohen's $d = 0.88$). An overall effect size was then

obtained by averaging the three effect sizes from previous studies investigating reasoning and attentional bias using emotional and neutral task conditions in individuals with delusions compared to healthy controls (Cohen's $d = 0.83$).

Based on the above studies and Cohen's (1992) recommendations, a power analysis was conducted using G*Power 3 software (Faul, Erdfelder, Lang, & Buchner, 2007), with an alpha of .05 (two-tailed), and an estimated effect size of 0.83, in order to estimate the sample size needed to achieve a power level of .80. This procedure yielded an estimated total sample size (both groups combined) of 48. Based on this estimation, 25 individuals with schizophrenia and 25 control participants were recruited in order to allow for sufficient power to determine group differences and examine relationships between performance on emotional versus neutral cognitive task conditions in each group.

Recruitment

Participants for this study included 25 individuals (outpatients) with schizophrenia and 25 demographically-matched control participants without a diagnosis of schizophrenia. Individuals with schizophrenia were recruited from area mental health facilities, psychiatric units at local hospitals, psychiatrists in private practice, and through newspaper advertisements. Flyers were also posted in local area establishments (e.g., grocery stores). Demographically-matched control participants were recruited from the local community using flyers, newspaper advertisements, and online advertisements. All materials used to recruit participants for this study included a statement that participants completing the study would be monetarily compensated.

Initial Exclusionary Criteria

The age range of participants for this study was restricted to adults between the ages of 18 and 60. The upper age cutoff was set at age 60 in an attempt to avoid potential confounds due to age-related declines in cognitive performance seen in the general population (Keefover, 1998). Additional demographic factors that were considered during recruitment included gender, race, and education level, due to the need to recruit control participants who were demographically well matched to the schizophrenia group. A brief phone screen was conducted to determine eligibility (see Procedures below).

Demographic Characteristics

The schizophrenia and control groups were well matched on most demographic variables (see Table 1). There was no difference in the gender composition between the groups, as each group consisted of 16 male and 9 female participants (χ^2 (1) = 0, p > 0.99). The mean age of participants was 39.61 (SD = 11.92) in the schizophrenia group and 39.57 (SD = 11.13) in the control group. There were no statistically significant differences between the groups with respect to age (F (48) = 0.0002, p = 0.99), or race (χ^2 (3) = 1.33, p = 0.86). Individuals in the schizophrenia group endorsed membership in the following racial categories: Caucasian (n = 14), African-American (n = 7), Hispanic (n = 1), Asian (n = 1), and Mixed/Biracial (n = 2); individuals in the control group endorsed: Caucasian (n = 14), African-American (n = 7), Hispanic (n = 2), and Mixed/Biracial (n = 2).

There was no statistically significant difference in estimated premorbid intelligence (t (48) = 1.41, p = 0.17) between the schizophrenia (M = 97.92, SD = 10.30) and control (M = 101.84, SD = 9.42) groups. The two groups differed, however, on years of education. Participants in the control group had significantly more years of education (M = 14.20, SD = 1.89) compared to the schizophrenia sample (M = 12.16, SD = 1.77; t (48) = 3.93, $p < .001$). Given that it is common for individuals with schizophrenia to achieve lower than expected educational attainment, parental educational level was also examined. There was no statistically significant difference between the groups on this measure (Hotelling's T^2 = 0.19, F (2, 37) = 0.09, p = 0.92).

Procedures

Phone Screen

Individuals responding to advertisements, flyers, and referrals from mental health professionals to participate in the study participated in a brief phone screening in order to assess eligibility for participation. Prior to answering any questions, all participants provided verbal consent to participate in the phone screen, with the understanding that they were free to discontinue participation at any point. Participants were then asked to provide basic demographic information including age, race, gender. Next, participants were read a list of past experiences, diagnoses, and other health factors that would prevent them from participating in the study. In order to protect their confidentiality, they were only required to answer "yes" or "no" after a series of statements, rather than indicate exactly which statement applied to them. Individuals in both the schizophrenia and control groups were excluded if they indicated that they: had undergone electroconvulsive therapy in the past 6 months; met diagnostic criteria for alcohol or

substance abuse in past month according to the DSM-IV-TR, or met criteria for DSM-IV-TR alcohol or substance dependence not in remission for the past 6 months; had a history of hospitalization for substance dependence (e.g., detox); experienced significant vision problems; had significant hearing problems; experienced significant problems with the use of their dominant arm; did not speak English as their first language; had a history of significant head injury; had a history of neurological illness (including stroke, seizures, brain tumor, and Parkinson's disease); or had a history of certain systematic medical diseases that may affect neurocognitive function (including AIDS, lupus, congestive heart disease, insulin-dependent diabetes). Individuals who did not fall between the ages of 18 and 60 were not eligible to participate. Additionally, control participants were excluded if they reported any first-degree relatives with a diagnosis of schizophrenia or a schizophrenia-spectrum disorder. Finally, individuals with schizophrenia who were not undergoing current treatment with antipsychotic medication were excluded. This was done in an effort to reduce the influence of untreated illness related symptoms (e.g. hallucinations), particularly on cognitive performance.

Laboratory Procedures

Individuals who completed the laboratory-based portion of the study participated in a psychological interview, completed self-report measures, and underwent a series of cognitive tests, all of which were administered or directly supervised by a graduate student in clinical psychology. All participants completed informed consent procedures prior to engaging in any of the above mentioned tasks. Visual acuity was then measured using a standard Snellen wall chart. No participant demonstrated visual acuity less than

20/50; therefore no participant was excluded from the study based on inadequate visual acuity. All participants were administered and found to score in the normal range or above on Ishihara's test for color blindness. Participants completed a brief measure assessing premorbid intellectual functioning, and all participants met cutoff criteria for study inclusion on this measure as well (estimated premorbid intelligence > 70).

Participants in both study groups underwent a brief demographic interview followed by a formal diagnostic interview. In the schizophrenia group, all participants met diagnostic criteria for schizophrenia, and no participant met diagnostic criteria for current co-morbid substance dependence. Participants in this group were not excluded if they reported co-morbid mood or anxiety disorders. All participants in this group reported current treatment with antipsychotic medication, 22 of whom were taking atypical antipsychotic medication, one of whom was taking typical antipsychotic medication, and two of whom were taking both typical and atypical antipsychotic medications. No participant in the schizophrenia group reported taking narcotic pain medication. Participants in the control group were excluded if they met diagnostic criteria for substance dependence (current), a psychotic disorder, or a mood disorder with psychotic features. This resulted in the discontinuation and exclusion of one participant. No individual in the control group reported current use of antipsychotic medication or narcotic pain medication. Individuals in either group reporting the use of prescription antidepressants or anxiolytics were not excluded. All participants were screened to ensure that no participant had used any psychotropic substance (except for the proper use of prescription medication) over the 48 hours prior to testing. Following the interview, individuals with schizophrenia were administered an additional semi-structured clinical

interview which assessed the presence and severity of positive and negative schizophrenia symptoms. All participants then completed a self-report measure of delusional thought. These measures are described in depth below.

The cognitive portion of the study included the administration of three cognitive tasks, each of which contained two conditions – a non-emotional (neutral) and an emotional condition. The jumping to conclusions and Stroop tasks were counterbalanced so that the starting condition was chosen at random to avoid potential confounds due to practice effects. While it was not possible to counterbalance the starting condition of the word recall task (the two conditions are intermixed within the same administration block), the order of emotional and neutral stimuli were randomized for each participant. The tasks consisted of: a jumping to conclusions (JTC) probabilistic reasoning task, an emotional Stroop task; and a word list recall task. These tasks are described in detail below. The cognitive tasks were embedded in a longer battery of tasks as part of a larger study. The average session lasted between 2.5 and 5 hours. Upon completion, all participants received payment (at the rate of $8 per half hour), as well as a debriefing statement.

Measures

Interview and Psychological Assessment

Informed Consent

All participants were required to provide written consent before participating in the study. Before signatures of both the participant and witness (the individual administering the study protocol) were obtained, consent was explained verbally and participants were given the opportunity to read the consent form and ask any questions.

They were also provided with a copy for their records. These forms, which contained identifying information, were stored in a secure filing cabinet separate from the study data, which was coded numerically to protect the identification of the participants.

The Structured Clinical Interview for the DSM-IV

The Structured Clinical Interview for the DSM-IV (SCID-I; First, Gibbon, Spitzer, & Williams, 1997b) is a semi-structured clinical interview used to assess whether an individual meets diagnostic criteria for DSM-IV-TR Axis I Disorders. This measure was used to confirm a diagnosis of schizophrenia in the schizophrenia group. It was also used to assess other Axis I disorders present in participants from both groups.

The Structured Clinical Interview for DSM IV Axis II Personality Disorders

The Structured Clinical Interview for the DSM-IV Axis II Personality Disorders (SCID-II) is a semi-structured clinical interview used to assess whether an individual meets diagnostic criteria for an Axis II Personality Disorder (First, Gibbon, Spitzer, Williams, & Benjamin, 1997a). The current study included selected sections from this measure used to screen for the presence of avoidant, paranoid, and schizotypal personality disorders. Previous research has suggested that these disorders may be genetically linked to schizophrenia (Fogelson et al., 2007; American Psychiatric Association, 2000). Items on the SCID-II are scored on a 3-point scale (absent/false = 1, subthreshold = 2, threshold/true = 3). In order to determine the presence of a categorical diagnosis based on criteria outlined in the DSM-IV-TR (American Psychiatric Association, 2000), the number of individual items with a rating of "3" in each subcategory is summed.

Structured Clinical Interview for Positive and Negative Symptom Scales

The PANSS (Kay, Opler, & Fiszbein, 1992; Kay, Fiszbein, & Opler, 1987) is a 30-item rating scale that assesses positive and negative symptoms in schizophrenia. This measure includes an optional semi-structured interview (Structured Clinical Interview for Positive and Negative Symptom Scales; SCI-PANSS) developed to be used with the PANSS. The SCI-PANSS contains four subscales: Positive symptoms, Negative symptoms, General Psychopathology, and a Composite scale (Kay et al., 1992). Each symptom or dimension assessed has distinct criteria which is used to rate severity on a seven-point Likert scale. The interview is typically conducted in three stages that include a rapport building stage, a formal semi-structured interview, and a subsequent scoring stage. Each of the 30 items of the SCI-PANSS is rated on a seven point scale with each point representing increased levels of symptom severity (1 = Absent, 2 = Minimal, 3 = Mild, 4 = Moderate, 5 = Moderate/Severe, 6 = Severe, 7 = Extreme). Symptoms assessed by the SCI-PANSS are well defined in the accompanying examiner's manual and scoring instructions.

According to reliability assessments of the SCI-PANSS, each individual item included in the measure correlates strongly with the appropriate scale total (Kay et al., 1987). Alpha coefficients of single items ranged from .64 to .84, and no gains in alpha coefficients were made by eliminating SCI-PANSS items. Inter-rater reliability correlations ranged between .89 and .94 (Kay, Opler, & Lindenmayer, 1988; Von Knorring & Lindstrom, 1995). Assessments of validity have shown strong discriminate and convergent validity, criterion validity, predictive validity, and concurrent validity (Kay et al., 1992). Individuals administering the SCI-PANSS in the current study

underwent training on this instrument through web-based videos provided by The PANSS Institute, LLC.

Reading Subtest of the Wide Range Achievement Test – 3rd edition

The Reading Subtest of the Wide Range Achievement Test, Third Edition (WRAT-3R; Wilkinson, 1993) is a list of 42 words presented in order of increasing difficulty. In order to reduce instances of phonemic decoding on this task, these words are irregular with respect to common rules of pronunciation. The WRAT-3R has been standardized with the Wechsler Adult Intelligence Scale – 3rd edition (WAIS-III). The WRAT-3R is scored by obtaining the sum of correctly pronounced words. From this value, a reading scaled score is obtained. This value corresponds to an estimate of verbal intelligence. Previous research has supported the use of the WRAT-3 Reading scaled score as an acceptable estimate of premorbid IQ (in this case, prior to the onset of schizophrenia), particularly in individuals from the lower range of IQ (Griffin, Mindt, Rankin, Ritchie, & Scott, 2002; Johnstone, Callahan, Kapila, & Bouman, 1996).

The 40-item Peters et al. Delusions Inventory

The Peters et al. Delusions Inventory (PDI; Peters et al., 1999a), which was originally based on The Present State Examination (Wing, Cooper, & Sartorius, 1974), was designed to measure delusional ideation in a healthy population. Items were chosen specifically for the purposes of measuring attenuated psychotic symptoms and sampling a wide range of delusional beliefs (Peters et al., 1999a). The PDI is designed to capture the dichotomous positive or negative endorsement of each item, but also taps into the dimensionality of the delusional belief. A respondent initially chooses a “yes/no”

response to each question, for example, “Do you ever feel as though there is a conspiracy against you?” If the respondent does endorse the item, he or she is then asked to rate the degree of distress, preoccupation, and conviction of the delusional thought on a five-point Likert scale (ranging from 0-5).

The PDI yes/no scores are obtained by adding up the number of “yes” items (assigned one point) and the number of “no” items (assigned 0 points), yielding a range of 0 to 40 points. Additionally, each dimension measured on the 5-point Likert scale can be scored, obtaining a range from 0 to 200 points. The grand total PDI score can be obtained by adding up the three dimension scores and the yes/no score, for a range from 0 to 640 points.

Scores on the PDI were normally distributed in a healthy population sample (n = 272; Peters et al., 1999a). No differences were found between males and females on yes/no scores, any of the dimensions, or on the total PDI score. Significant inverse relationships with age were found on yes/no scores, the distress and preoccupation subscales, as well as a trend between age and the conviction subscale. The PDI was found to have good internal consistency (0.88), and good test-retest reliability (0.82) was demonstrated in a subset of the sample who was asked to retake the measure six months to a year later. The measure was also found to have good convergent validity, sharing 52% to 58% of common variance with the Delusions-Symptoms-State-Inventory (Foulds & Bedford, 1975); the Schizotypal Personality Scale (Claridge & Broks, 1984) and the Magical Ideation Scale (Eckblad & Chapman, 1983). Criterion validity was established by administering the PDI to a group of currently deluded, psychotic individuals (N = 20).

Ratings on the total number of items endorsed and on all scales of the PDI were statistically significantly higher in this group (Peters et al., 1999a).

Cognitive Tasks

Stroop Task

A computerized Stroop task with two conditions - emotional and neutral - was administered. Participants were seated 18 inches away from a 22-inch CRT monitor (Iiyama Vision Master Pro 514) and PC computer. A chin/forehead rest was used in order to minimize head movement and ensure that each participant was within 8" of a microphone which was used to record the reaction time of the onset of the vocal response.

Several variations of the emotional Stroop task exist. Emotion and non-emotion (neutral) words for the current study were selected from the Affective Norms for English Words (ANEW) word list (Bradley & Lang, 1998). The ANEW word list consists of several hundred English words that have been rated on dimensions such as emotional arousal and emotional valence. In order to maximize the potential to detect differences between conditions, an equal number of high arousal negative and positive words were used in the emotional condition. The non-emotional condition consisted of an equal number of neutral words. Words in both conditions were matched on word frequency and word length. Word matching and selection was achieved using an online program designed to be used in conjunction with the ANEW list (Siegle, 1994).

Following procedures described by Compton et al., words were presented in two blocks (one emotional, one neutral), as previous research has demonstrated that emotional words become harder to ignore when they are grouped together rather than

intermixed with neutral words (Compton et al., 2003). In order to control for possible habituation effects within participants, no word was ever repeated. In both conditions, participants were told to orally state the font color of the words, which appeared in one of four color choices: red, green, blue, or yellow.

A total of 100 trials were administered, equally divided into 50 trials of each condition. Though conditions were blocked according to emotional versus non-emotional words (counterbalanced order by participant), within each condition, words were presented in a random order that differed for each participant. Therefore, it was possible that several negative or positive words appeared in succession within the emotion condition. Stimuli were presented one at a time in uppercase 40-point Arial font in the center of the computer screen against a black background. Each stimulus was immediately preceded by a fixation cross in the middle of the screen (lasting 250 ms). Stimuli were presented for a maximum of 4 sec, or until the participant orally stated his or her response into a microphone, triggering the word to disappear immediately. The fixed intertrial interval lasted for 2000 ms and consisted of a blank, black screen.

Before the task began, the following instructions appeared on the computer monitor and were read out loud to the participant: “Welcome to the color-naming task. When you see a word appear on the screen, please state the *font* color of each word presented as quickly as you can without making mistakes. Remember, you are to state the color of the font and ignore the word itself.” Participant’s verbal responses were measured via a voice-activated microphone and recorded by the computer to millisecond accuracy in order to track reaction time. Responses were manually coded by the experimenter for accuracy during the intertrial interval. A 10 trial practice session

(consisting of neutral words) preceded the administration of the actual task in order to familiarize the participant with the task. During the practice session, participants were given verbal feedback concerning their performance from the administrator. The total amount of time needed to complete the task ranged from five to seven minutes.

Reaction time (RT) data from each participant was filtered so that only correct trials were included in the RT data used in the analyses. This was done in an effort to exclude trials that may have rewarded participants for answering quickly without regard for accuracy and penalized participants for taking the time to provide a correct response. Following this procedure, accuracy scores were reviewed to ensure that any participant with an accuracy score around chance (< 33%), within either condition, would be excluded. Examination of accuracy scores revealed that, within each condition, no participant obtained a score below 64%, therefore no participant was excluded for failing to adequately attend to or comprehend the task. This filtered RT value served as a general measure of performance, as indicated by response efficiency in correct trials. The expected emotion effect in both groups is a longer average RT in the emotional condition compared to the neutral condition.

Word Recall Task

A word recall task was administered as a measure of attentional bias. In a previous study investigating attentional bias toward threat-related, depression-related, and neutral words in three groups (individuals with delusions, individuals with depression, and controls), participants viewed 36 words printed on small cards (12 from each respective category), one at a time (Bentall et al., 1995). Words were intermixed and presented in a random order that differed in each participant. They were then asked to

remember as many words as possible. Number of words recalled was recorded and repetitions were noted as well. Attentional bias was determined by comparing the mean number of words recalled in each condition across groups. If a group recalled a greater number of words from a given list compared to the recall of other groups, this was thought to indicate the presence of an attentional bias. In order to determine whether there were specific recall biases within the individual groups, the mean number of words recalled from each group of words was compared within participant groups (Bentall et al., 1995).

A variation of this task was employed in the current study. A total of 18 emotional words (half positive and half negative) and 18 non-emotional words were presented in a single presentation format, for a total of 36 words. Words chosen for this task were generated using the same procedure described above to choose words for the emotional Stroop task. In order to avoid carry over effects, no word used on the Stroop task was repeated in the word recall task. Instead of employing a card version of the task, the current study used a computerized version of the task. Before the task, participants saw following instructions on the computer screen: "You will see a group of words presented one at a time on the screen. Please look at each word carefully, because immediately after *all* words are presented, you will be asked to remember as many of these words as you can, in any order." All 36 words were then presented singly on the screen at a fixed rate (1000 ms per word) in a random sequence that differed for each participant. Following each word, a blank screen appeared for 1000 ms before the presentation of the next word. Words appeared in black ink against a white background in 36-point Arial font in the center of the screen. Words appeared in lowercase lettering. After all of the words were

presented, a free recall trial took place. Participants were asked by the experimenter to state aloud all of the words that they remembered, in any order. Responses were recorded verbatim by the experimenter. Raw scores indicated how many words a participant recalled in each condition, which serves as a general measure of sustained attention and subsequent recall of visually presented verbal information. More words recalled in one condition compared to another suggests an attentional bias. The expected emotion effect in both groups is for more emotion words to be recalled as compared to neutral words. This task took approximately 5 minutes to complete.

Jumping to Conclusions Probabilistic Reasoning Task

Different variations of the jumping to conclusions task (JTC) exist, most of which are based on the Bayesian model of reasoning (Fine, Gardner, Craigie, & Gold, 2007). This model describes reasoning as rooted in one's degree of belief based on probability as determined by the available empirical evidence (Oaksford & Chater, 2003). The original and most commonly used version of the task is the 'beads in a jar' paradigm, described by Huq and colleagues (1988) in their study with deluded schizophrenia patients. This task requires individuals to decide which jar of colored beads a series of individual beads (which appear to be drawn in random sequence) is being drawn from. Participants are usually presented with two jars with opposite ratios (most commonly 85:15 and 15:85) of colored beads. The jars are then hidden and an experimenter 'draws' a pre-selected series of beads one at a time. Some variations of the task require the participant to state which jar is being drawn from when they are sure that they have the correct answer ('draws to decision' methodology), while others present all participants

with the same series of beads and ask that they rate their degree of certainty that the beads come from a particular jar (‘draws to certainty’ method).

A ‘realistic’ version of the beads task was developed by Dudley and colleagues. Instead of using beads in a jar, these authors read aloud unambiguous male and female names to participants, who were told that the names originated from a list of students from either a mostly girls (60 girls and 40 boys) or mostly boys (60 boys and 40 girls) school. When participants were confident they knew which list names were being read from, they were instructed to state their answer aloud. In order to increase task demands, these authors also altered the 85:15 ratio typically used in the beads task to a 60:40 ratio (Dudley et al., 1997b). In a separate study, these authors describe an emotional counterpart version of the neutral names task. In this task, participants are read aloud personality attributes (either negative or positive) and told that these traits originate from a hypothetical survey conducted about an unknown individual. On the ‘mostly good’ survey, 60 people made positive comments and 40 people made negative comments; on the ‘mostly bad’ survey, the ratio is reversed. Participants are asked to decide which survey the personality attributes originate from when they believe they know the correct answer (Dudley et al., 1997a).

While the beads task and the ‘realistic’ names task are both considered neutral versions of the JTC reasoning bias, the names task was chosen for the current study. This was done in an effort to ensure that the emotional and non-emotional versions of each task were as similar as possible. Following the procedures described by Menon et al., three trials of each JTC task were administered. These authors used a random number generator in order to determine the sequence of names and personality attributes (Menon

et al., 2006). The current study used the same sequences described by these authors, using identical sequences across both conditions. The order of the emotional and neutral conditions was counterbalanced by participant.

In a recent meta-analysis investigating different methods for measuring the JTC reasoning bias, it was reported that a tendency to gather less evidence (measured by the 'draws to decision' method) was reliably associated with delusional symptomatology, while other indices of performance investigated did not discriminate well between individuals with and without delusions (Fine et al., 2007). According to this method, the fewer draws to decision (beads task), or pieces of information (realistic task) requested, the greater the JTC bias. Therefore, the current study used draws to decision as the primary measure of the JTC bias. As there were three trials in each condition, a total score for was obtained by averaging performance across trials, yielding two outcome scores for each participant (JTC neutral task mean score and JTC emotional task mean score). While these scores represented overall proficiency on the task, the emotion effect referred to the difference in performance between the two conditions. This task lasted between 5 and 10 minutes.

RESULTS

Measures of Symptom Severity

In terms of general illness characteristics, participants in the schizophrenia group reported an average illness duration of 16.17 years (SD = 11.25) and an average age of illness onset of 24.20 years (SD = 11.00). Individuals in the schizophrenia group were rated on symptom severity using the SCI-PANSS. The SCI-PANSS Positive Symptom Scale mean was 20.36 (SD = 5.20), the Negative Symptom Scale mean was 18.08 (SD = 4.23), the General Psychopathology Scale mean was 37.08 (SD = 6.91), and the mean Composite score was 2.28 (SD = 6.76). On the individual SCI-PANSS item assessing delusion severity, the group mean was 4.04 (SD = 1.24), which indicated symptom severity in the moderate range. Examination of the raw scores among individual participants in the schizophrenia group revealed that all but two attained a score of at least 3 (mild range) on this item, indicating that almost all of the 25 schizophrenia participants endorsed the presence of delusional thought (within the past 6 months) beyond the absent/minimal ranges.

Individuals in both the control and schizophrenia group completed a multi-dimensional measure of delusion-proneness (PDI). The scores were as follows for the schizophrenia group: mean PDI Total score of 185.48 (SD = 113.77), PDI Yes/No score = 15.64 (SD = 8.79), PDI Distress score = 52.72 (SD = 33.75), PDI Preoccupation score = 52.84 (SD = 33.24), and PDI Conviction score = 64.28 (SD = 41.16). In the control group, the scores were: PDI Total score = 52.64 (SD = 48.64), PDI Yes/No score = 5.84

(SD = 4.62), PDI Distress score = 11.64 (SD = 13.29), PDI Preoccupation score = 15.52 (SD = 15.14), and PDI Conviction score = 19.64 (SD = 17.54). See Table 1.

PDI scores were examined between groups to determine whether the two groups self-reported different levels of symptomatology on this measure. It was expected that individuals in the schizophrenia group would report higher PDI scores on all indices. According to Levene's Test for equality of variances, guidelines for homogeneity of variance ($p > 0.05$) between the two groups were not met for any of the PDI indices. Therefore, a Kruskal-Wallis Test was used to examine between group differences on the PDI. This test revealed that the schizophrenia group scored statistically significantly higher on all PDI indices, including: PDI Total score (χ^2 (1) = 18.64, $p < .001$), PDI Yes/No score (χ^2 (1) = 16.49, $p < .001$), PDI Distress score (χ^2 (1) = 21.37, $p < .001$), PDI Preoccupation score (χ^2 (1) = 17.58, $p < .001$), and PDI Conviction score (χ^2 (1) = 17.98, $p < .001$). In the schizophrenia group, PDI Total scores ranged from 6 to 434 (M = 185.48, SD = 113.77), whereas in the control group PDI Total scores ranged from 0 to 186 (M = 52.64, SD = 48.64). See Table 1.

Next, correlations were conducted in order to explore the relationships between selected measures of clinical symptoms in the schizophrenia group (control participants could not be included in this analysis due to the absence of SCI-PANSS scores). Since the PDI total score includes all other PDI subscales scores, this score was chosen for the purpose of exploring the relationship between self-reported delusional thought and all primary SCI-PANSS scores as well as the individual delusions item from the SCI-PANSS. Examination of indices of normality revealed skewness and kurtosis values within acceptable ranges for all variables. A Bonferroni correction was applied to an

alpha value of 0.05 to control for multiple comparisons (0.05/5 = 0.01). Results revealed a statistically significant relationship between the PDI total score and the SCI-PANSS Positive symptom score ($r = 0.72$, $p < 0.001$), PANSS Composite score ($r = 0.69$, $p < 0.001$) and SCI-PANSS delusion score ($r = 0.58$, $p = 0.002$). The relationship between the PDI total score and the SCI-PANSS General score showed a statistical trend that did not meet criteria for significance given the conservative correction applied ($r = 0.44$, $p = 0.03$). These results indicate good reliability between the self-report measure of delusion propensity and observer ratings of positive symptoms (including delusions) in this sample. The SCI-PANSS Negative symptom score was not statistically significantly related to the PDI total score ($r = -0.21$, $p = 0.31$). This was expected, given that negative symptoms of schizophrenia include those generally thought to be unrelated to delusional thought (e.g., blunted affect, stereotyped thinking).

Cognitive Tasks

Primary Hypotheses

In order to test the primary set of hypotheses exploring potential relationships among group, task performance, and delusion-propensity (as measured by the PDI total score), statistical analyses were conducted using SPSS 16.0 software. All data sets were complete for all participants ($n = 50$), so problems with missing data were not applicable. Since PDI total scores were used in all analyses of the main hypotheses, skewness and kurtosis values were examined in both groups ($n = 25$); none exceeded recommended guidelines (greater than +/- 2; Tabachnick & Fidell, 2007). Indices of normality specific to each task are reported below.

Stroop Task Performance

To test the primary hypotheses within this task, a mixed ANCOVA and a series of paired-samples t tests were performed. In the mixed ANCOVA, one independent variable (IV) was group (schizophrenia or control), the second IV was task condition (emotional or neutral), the PDI total score was entered as a covariate, and the dependent variable (DV) was reaction time. Indicators of normality were examined to determine if recommended assumptions for this statistical test were met. An examination of skewness and kurtosis in each of the two groups revealed values that fell within recommended guidelines of +/- 2 (Tabachnick & Fidell, 2007). Box's M Test for equality was significant ($p = 0.009$) indicating that the assumption of equal covariance values among the two levels of the dependent variable across groups was not met. According to Levene's Test for equality of variances, the assumption of homogeneity of variance ($p > 0.05$) in the groups was met. Given that most indices of normality fell within recommended guidelines, data was not transformed prior to analysis.

It was hypothesized that individuals with schizophrenia would respond more slowly (e.g., longer RT) on both the emotional and neutral versions of the Stroop task compared to the performance of controls on these tasks. In order to address this question, the main effect of group (collapsing the two conditions) was examined, which revealed a statistical trend for significance in the predicted direction (F (1, 46) = 2.91, $p = 0.10$, $\eta^2 = 0.06$). In order to address the next hypothesis, paired samples t-tests were conducted. It was hypothesized that, within each group, there would be a statistically significant emotional effect between task conditions, indicated by a difference in performance on the emotion (compared to neutral) task condition. This hypothesis was partially supported, as

results revealed that within the schizophrenia group, participants demonstrated a statistically significant increase in reaction time on the emotional condition (t (24) = 2.19, p = 0.04), while controls showed no reaction time difference between the two conditions (t (24) = 1.10, p = 0.28; see Figure 1). The next hypothesis was addressed by examining the condition by group interaction from the mixed ANCOVA in order to determine whether the predicted emotion effect would be larger in the schizophrenia group. This hypothesis was not supported (F (1, 46) = 0.01, p = 0.93, $\eta^2 < 0.01$). In order to investigate the fourth hypothesis that the emotion effect would increase as the severity of delusional proneness increased for all participants (regardless of group), the condition by PDI total score interaction term was examined. Results did not support this hypothesis (F (1, 46) = 2.12, p = 0.15, $\eta^2 = 0.04$). See Tables 2, 3, 4, 5, and 6.

Word Recall Task

The above described analyses were then repeated in order to investigate our primary hypotheses with the word recall task. An examination of indices of normality, including skewness and kurtosis values, Box's M Test for equality of covariance among dependent variables, and Levene's Test for equality of variances indicated that all values were within acceptable ranges. A mixed ANCOVA with group at the first IV, task condition as the second IV, number of words recalled as the DV, and PDI total score as a covariate was conducted. The hypothesis that individuals with schizophrenia would recall fewer words on both the emotional and neutral conditions compared to controls was supported (F (1, 46) = 7.28, p = 0.01, $\eta^2 = 0.14$). Paired-samples t tests were conducted to determine whether there was a statistically significant emotion effect (indicated by recall of fewer neutral compared to emotion words) in either group. Results revealed no

difference in the schizophrenia (t (24) = 0.00, p = 1.00) or control groups (t (24) = -0.55, p = 0.59). Results of the mixed ANCOVA did not indicate support for the hypothesis that there would be a larger emotion effect in the schizophrenia group compared to the control group (F (1, 46) = 0.98, p = 0.33, η^2 = 0.02). Next, the hypothesis that the emotion effect would increase as the severity of delusional proneness increased for all participants (regardless of group) was addressed. The condition by PDI total score interaction from the mixed ANCOVA revealed that this hypothesis was not supported (F (1, 46) = 0.95, p = 0.33, η^2 = 0.02). See Tables 2, 3, 4, 5, and 6.

Jumping to Conclusions Probabilistic Reasoning Task

Finally, the same set of analyses was repeated with the data from the JTC task. In the mixed ANCOVA, group was the first IV, task condition was the repeated measures IV, number of draws to conclusion served at the DV, and PDI total score was the covariate. An examination of skewness and kurtosis statistics indicated values within acceptable ranges for all DV's. However, values from Box's M Test for equality of covariance among dependent variables (p = 0.01) and Levene's Test for homogeneity of variance between groups were statistically significant (JTC neutral: p = 0.02; JTC emotional: p = 0.003). Data (DV scores) were then transformed using a square root transformation, after which all indices of normality fell within acceptable ranges.

The hypothesis that individuals with schizophrenia would require fewer draws to reach a conclusion on both the emotional and non-emotional versions of the JTC task compared to controls was supported (F (1, 46) = 4.82, p = 0.03, η^2 = 0.10). Paired samples t-tests, which were conducted to determine whether there was a statistically significant emotion effect within each individual group, revealed no emotion effect in

either the schizophrenia (t (24) = 0.99, p = 0.33) or control (t (24) = 0.63, p = 0.53) group. Examination of the condition by group interaction effect from the ANCOVA revealed that the third hypothesis (emotion effect would be larger in the schizophrenia group) was not supported (F (1, 46) = 0.34, p = 0.86, η^2 = 0.001). The fourth hypothesis was that the emotion effect would increase as the severity of delusional proneness increased for all participants. The condition by PDI total score interaction effect revealed that this hypothesis was not supported (F (1, 46) = 0.62, p = 0.43, η^2 = 0.01). See Tables 2, 3, 4, 5, and 6.

Exploratory Analyses

Cognitive Tasks: Valence

In addition to the primary hypotheses discussed, exploratory analyses were conducted in order to examine relationships among secondary features of the measures, including valence of emotional stimuli (positive or negative), which could be analyzed separately in both the Stroop and word recall tasks. Stroop data was analyzed first using a mixed ANCOVA. An examination of skewness and kurtosis within the groups revealed values exceeding recommended cutoffs (greater than +/- 2) for skewness in negative RT: control group, and kurtosis in negative RT: control group, positive RT: control group, and positive RT: schizophrenia group. Box's M test for equality was significant (p = 0.008), indicating that the assumption of equal covariance values between levels of the dependent variable was violated. Levene's Test for homogeneity of variance between groups was not statistically significant. For the purposes of these exploratory analyses, the ANCOVA was performed with the caveat that not all recommended assumptions of normality were satisfied. In the mixed ANCOVA, group served as an IV, valence (positive or negative)

was the second IV, RT was the DV, and PDI total score was entered as a covariate. An examination of main effects revealed that the effect of valence was statistically significant (F (1, 46) = 7.88, p = 0.007, η^2 = 0.15), indicating that overall performance on this task was impacted by valence. Both groups performed better, that is they evidenced lower RT's, for positive words. However, the valence by group interaction was not statistically significant (F (1, 46) = 1.83, p = 0.18, η^2 = 0.04), nor was the valence by PDI total score interaction (F (1, 46) = 0.28, p = 0.64, η^2 = 0.01), suggesting that the groups did not perform differently as a function of valence, and the effect of valence was not related to level of delusion-proneness. See Table 2 and 7.

Exploratory analyses were conducted to examine potential relationships among task valence, group, and PDI total score in the word recall task. An examination of skewness and kurtosis in each of the two groups revealed values that fell within recommended guidelines of +/- 2 (Tabachnick & Fidell, 2007), with the exception of the positive words variable in the schizophrenia group (kurtosis value = 2.98). Box's M Test for equality was not significant, nor were the values from Levene's Test for equality of homogeneity of variance in the groups. Because there was only one relatively minor violation of normality detected, a mixed ANCOVA was performed with group as one IV, valence as the second IV, number of words recalled as the DV, and PDI as the covariate. An examination of main effects revealed that the effect of valence was not statistically significant (F (1, 46) = 1.07, p = 0.31, η^2 = 0.02). The valence by group interaction was not statistically significant (F (1, 46) = 0.20, p = 0.90, η^2 < 0.01), nor was the valence by PDI total score interaction (F (1, 46) = 1.01, p = 0.32, η^2 = 0.02). See Table 2 and 8.

PDI Dimension Scores

In order to determine whether any particular subscale(s) of the PDI was more sensitive to differences in performance on the three sets of cognitive tasks, exploratory analyses were conducted. A series of mixed ANCOVAs were performed, and in all of these analyses, one IV was group, a second IV was condition (emotional or neutral), and the DV was the measure of performance in the task being examined in that analysis (i.e., emotional Stroop RT, words recalled, or draws to conclusion in the JTC task). Three analyses were conducted for each task, one with each of the PDI subscales (distress, preoccupation, or conviction) serving as the covariate. The condition by PDI subscale interaction and the group by condition by PDI subscale interaction were examined in each analysis to determine whether task performance differed as a function of these individual subscales, which were grouped together in the main analyses. None of these interactions of interest were statistically significant; see Tables 9, 10, and 11.

DISCUSSION

The aim of the study was to investigate the influence of emotional content on cognitive processing in individuals with schizophrenia and demographically matched healthy controls. Previous research has established that specific cognitive deficits related to reasoning and attention processes are often observed in individuals with delusions (e.g., Bell et al., 2006), a symptom present in a majority of individuals with a diagnosis of schizophrenia. Therefore, three tasks thought to capture various types of cognitive biases in these cognitive domains were chosen for inclusion in the current study: an emotional Stroop task (selective attention to emotionally salient stimuli), a word recall task (preferential recall of emotional stimuli), and a jumping to conclusions task (a bias toward hasty decision making in probabilistic reasoning). In order to investigate the influence of concurrent processing of emotion during performance on the cognitive tasks described above, an emotional and neutral version of each task was administered. As subclinical delusional thought also appears to be present in individuals without a clinical diagnosis of a psychotic disorder (Verdoux & van Os, 2002), delusion-proneness was measured in both groups of participants in the current study. Data was subsequently analyzed in order to investigate group differences in cognitive performance, as well as any emotion effect (a discrepancy between emotional and neutral conditions in each set of tasks) that may have been present in the groups. The relationship between delusion-proneness and the emotion effect was also investigated. Finally, exploratory analyses

were conducted to examine the effect of other task characteristics on performance, including task valence and dimensions of delusion-proneness.

Based on previous literature describing cognitive deficits in schizophrenia, specifically in relation to delusions (e.g., Rocca et al., 2006), it was hypothesized that individuals in the schizophrenia group would perform more poorly on all cognitive tasks compared to the performance of the control group. The analyses of this hypothesis therefore combined performance on the emotional and neutral versions of each respective task. This hypothesis was generally supported across all tasks, though results from the emotional Stroop task revealed a statistical trend for significance in the predicted direction (small effect size), while results from the other two tasks revealed statistically significant (alpha levels < 0.05) findings and effect sizes in the medium range. With this caveat in mind, results indicated that individuals in the schizophrenia group performed more poorly on the cognitive tasks compared to individuals in the control group. In the emotional Stroop task, this was indicated by a trend for the schizophrenia group to demonstrate longer response times to both emotional and neutral stimuli combined. In the word recall task, poorer overall performance was indicated by the tendency of individuals in the schizophrenia group to recall fewer words in both conditions combined. On the JTC task, individuals with schizophrenia requested less information before reaching a conclusion, again on both task conditions combined, as compared to controls. This pattern of results was not surprising given the ample evidence that individuals with schizophrenia typically display a variety of cognitive deficits, as well as the fact that tasks in this study were specifically chosen based on the research literature on individuals with delusions. Overall, results indicated that the two groups in this study performed as

expected on the cognitive tasks with respect to previous findings described in the research literature.

The second hypothesis specifically tested for the presence of an emotion effect within each group separately for each set of tasks. Results of data analyses for the word recall task and the JTC task revealed nonsignificant findings, indicating that an emotion effect was not detected for these tasks in either group. On the emotional Stroop task, an emotion effect was observed in the schizophrenia group. Specifically, individuals in this group performed statistically significantly worse in the emotional version of the task, as indicated by increased RT for emotion words compared to neutral words. However, no emotion effect was observed in the control group on the emotional Stroop task. Overall, these results were somewhat unexpected. It was anticipated that both groups would show an emotion effect in all three sets of tasks. This hypothesis was based on previous research indicating that the presence of emotional content in the specific cognitive tasks employed typically results in performance deficits in healthy controls and a variety of clinical groups, including those with delusions. In the control group of this study, the emotion effect was not observed on any of the tasks, and in the schizophrenia group it was only observed in the emotional Stroop task. One point that was considered in interpreting these findings is that previous investigations of the emotion effect in the word recall and JTC task are fewer in number compared to the emotional Stroop task, which is much more widely studied and standardized. Nevertheless, previous reports have demonstrated instances in which the performance of both healthy controls and individuals with delusions are affected by emotional content in the emotional Stroop

(Bentall & Kaney, 1989; Williams et al., 1996), word recall (Mathews & Barch, 2004; Bentall et al., 1995) and JTC tasks (Dudley et al., 1997b).

The hypothesis that the emotion effect would be larger in the schizophrenia group as compared to the control group was also not supported. The interactions of group by emotion condition from all three tasks were not statistically significant, and an inspection of effect sizes revealed no hint of an effect (η^2 values ranges from 0.00 to 0.02) in any of the tasks. While it appears that very few previous studies have investigated this specific question using these tasks, several theoretical explanations for delusions predict that individuals with delusions will have more difficulty processing emotionally salient material during cognitive performance compared to controls (e.g., Freeman & Garety, 2003). Therefore, these results were somewhat unexpected, though less so when considered in the context of the other findings and after accounting for the potential influence of task constraints.

Several factors are relevant to understanding the apparent lack of a difference in the magnitude of an emotion effect between the groups. The most salient of these factors is that an emotion effect was not observed in either of the groups, with the exception of the emotional Stroop task, for which the effect was only present in the schizophrenia group. Given that the emotion manipulation generally did not produce the expected effects on performance, the absence of a larger emotion effect in the schizophrenia group made sense, especially for the JTC and word recall task. In order to better explain these findings, each task will be considered individually to account for task specific characteristics of potential relevance.

Examination of results of the word recall task revealed that, not only did the schizophrenia group fail to demonstrate an emotion effect, this group had identical mean scores on the emotional and neutral conditions (2.72 words). The control group showed a similar pattern of performance, though qualitatively, there was a very small difference in mean scores between conditions that was not statistically significant. This finding was partially consistent with a previous study of attentional biases in a word recall task in individuals with persecutory delusions, individuals with depression, and healthy controls (Bentall et al., 1995). These authors reported that the delusion group showed a bias toward recall of threat-related and depression-related words, while controls did not. The current study did not detect a bias in either group, however important differences in group composition and task design may partially account for these seemingly discrepant findings. Bentall et al. (1995) limited their delusion group to those with persecutory delusions, while the current study included individuals with other subtypes of delusions. Furthermore, in the Bentall et al. study, emotion words were limited to those that were thought to be personally relevant (i.e., threat-related) to the persecutory group (depression words were included for the depression group), while the current study included general emotion words equally mixed between positive and negative valence and matched for intensity. This was done to account for the inclusion of a mixed delusion group, and to ensure that the emotion task was also relevant to controls.

While Bentall et al. (1995) found no recall bias in their control group, other studies have reported an effect of emotional words in similar recall tasks with a healthy control group using general positive and negative emotion words (e.g., Mathews & Barch, 2004). These authors sought to compare the performance of healthy controls to

that of schizophrenia patients with the hypothesis that patients with specific *negative* symptoms would fail to show an emotion effect. These authors found that both the control group and the schizophrenia group showed an emotion effect, and that this effect was not larger in one group or the other. Interestingly, the severity of blunted affect in patients was associated with a smaller emotion effect in this study, while positive symptoms of schizophrenia were unrelated to the magnitude of the emotion effect (Mathews & Barch, 2004). Similarly, the current study also failed to find a relationship between delusions (a positive symptom) and the magnitude of emotion effect in the word recall task. It should be noted that the recall task employed by Mathews and Barch (2004) was an incidental-encoding task which required participants to evaluate words for valence and intensity immediately followed by a surprise free recall trial. In contrast, the task used in the current study was a passive task that merely exposed participants to each word very briefly, followed by a free recall trial. This was done in an effort to reduce the influence of task complexity and/or the use of memory strategies in healthy controls on recall performance. However, it is possible that the effortful processing component of the task used by Mathews and Barch was a more effective means for investigating the effect of concurrent emotion processing during a traditional cognitive task. Overall, it is possible that using a task that 1) included words that were more salient to individuals with delusions and 2) using a task with a more active encoding component may have resulted in an emotion effect in the current study.

Previous studies of attention bias have suggested that valence may influence the degree of bias to particular emotion words (Strauss & Allen, 2009), so this factor was examined in the current study. Within the word recall task, an analysis of valence effects

indicated that participants in both groups performed similarly, regardless of whether emotion words were positive or negative, and valence was not related to level of delusion-proneness. Therefore, it is unlikely that combining positive and negative words in the emotion condition had an appreciable influence on the results of the word recall analyses.

Examination of the lack of an emotion effect in the JTC task both within and between the groups revealed several possible factors that may have contributed to this finding. One factor of interest was task type. While the majority of previous research has utilized the traditional 'beads' version of the task, the current study employed the less frequently used 'names' version as the neutral condition. This task was designed to be used in comparative studies of the emotionally salient JTC bias as it serves as a more realistic neutral comparison task than the beads task (Dudley et al., 1997a). In the first study using the names task, it was reported that individuals with delusions required less evidence before coming to a conclusion compared to healthy controls, which was noted to be consistent with previous findings from the beads task (Dudley et al., 1997a). These authors also reported that mean JTC scores for the beads and names versions of the neutral task were similar in their sample (Dudley et al., 1997b). Thus, there is support for the notion that the names task is comparable with the beads task. Nevertheless, given that the majority of prior research that influenced the hypotheses concerning JTC performance in the current study employed the beads task, the use of the names task cannot be ruled out as a possible factor contributing to the results of the current study.

The emotional JTC task used in the current study was based on the 'survey' task described by Dudley et al. (1997a), however, while these authors reported an emotion

effect in both the delusion and control groups when contrasting the neutral names task with the emotional survey task, the current study failed to find such an effect. These authors did not include an analysis of the comparison of the size of the emotion effect between groups in this article. However this information was available in a recent review article (Fine et al., 2007) and these authors reported that there was no difference between the size of the emotion effects in the psychiatric versus nonpsychiatric groups in the Dudley et al. (1997a) study, which is consistent with findings from the current study. In a study conducted by Warman and colleagues (2007) using the emotional JTC task, it was reported that individuals with delusions gathered significantly less information than control participants in both the neutral and emotional tasks. However, unlike Dudley et al. (1997a), these authors did not detect the presence of a statistically significant emotion effect in either group. While our findings regarding the lack of an emotion effect in the JTC task are therefore consistent with that of Warman et al. (2007), it should be noted that they used a slightly different version of the survey task that added a self-referent component to the emotional stimuli presented. Taken together with findings from the current study, it appears that the emotional version of the JTC task has yielded inconsistent results regarding effectiveness of the task in producing an emotion effect.

Other possible factors that may have contributed to the lack of a statistically significant emotion effect in the JTC task include the limit placed on information available to a participant before a conclusion is reached, and the limited number of participants who displayed an extreme responding style. In the current study, participants were given up to 10 possible pieces of information (names in the neutral condition and personality traits in the emotional condition) before they were essentially forced to make

a decision. Though previous studies using the JTC task often do not state whether or not such a limit was in place, some have reported a limit of 20 units of information using the specific versions of the task employed in the current study (Warman et al., 2007). In the current study, a somewhat arbitrary cutoff of 10 pieces of information was selected based on the notion that basic limits on working memory would limit the usefulness of increasing units of information past a certain point. In other words, since the current study did not include a memory aid, it was reasoned that by the time a participant was given a 15^{th} clue, they would likely have forgotten the first clue. Coupled with previously published mean and standard deviation scores on this task, 10 units of information appeared to be a reasonable cutoff point. However, an examination of the raw data revealed that a number of participants, particularly in the control group, requested the maximum 10 pieces of information on both the neutral and emotional conditions. It is possible that employing a limit of 20 possible pieces of information would have yielded larger group differences, thus affecting the results of statistical analyses related to the presence and magnitude of emotion effects.

Another trend that became apparent when examining the raw scores on the JTC task is the relatively low number of participants showing a "jumping to conclusions reasoning style," which is defined as coming to a conclusion after two or fewer trials (Garety et al., 2005). While this index of performance was not used in any of the data analysis, an examination of these scores revealed that participants in the current study did not perform as expected given previous reports that 40 – 70% of individuals with delusions make decisions after one or two draws (White & Mansell, 2009). In the current study, the percentage of participants in the schizophrenia group (most of whom reported

delusions) with this JTC reasoning style was noticeably lower (12% in the neutral condition; 20% in the emotional condition). Furthermore, it has been reported that between 10 – 20% of healthy controls show the JTC reasoning style (Freeman, 2007), however in the current study no controls demonstrated this pattern of performance on either task condition. Therefore, it appears that while mean scores on the task obtained in the current study are comparable with past reports, this may be more related to the limit placed on available pieces of information combined with relatively few participants demonstrating the JTC reasoning style.

Findings from the JTC and word recall task showed no emotion effect within groups, and no difference in the size of the emotion effect between groups. It is somewhat puzzling, however, that the schizophrenia group did not show a larger emotion effect than the control group on the emotional Stroop task, considering that this group demonstrated the predicted emotion effect, while the control group did not. However, an examination of the means and standard deviations of Stroop RT values in both groups provides qualitative information about observed performance patterns in the groups that may shed some light on this finding. Although the difference in RT values between conditions was statistically significant only in the schizophrenia group, both groups performed faster in the neutral condition and displayed similar amounts of variability among RT values. The degree of the difference between neutral and emotional conditions was slightly larger in the schizophrenia group, which accounts for the finding that this group showed the predicted emotion effect. When this effect is compared between groups however, there is no hint of a difference, and this is likely due to the fact that overall, the groups performed very similarly.

In what appears to be the first study using the emotional Stroop task to investigate attentional bias in individuals with delusions, Bentall and Kaney (1989) reported that individuals with persecutory delusions showed a greater degree of interference (i.e. a larger emotion effect) for paranoia words compared to both a depression and control group. Interestingly, these authors reported that when paranoid words and depressive words were combined to form an emotional condition and then compared to the neutral words, there were no differences in amount of interference among the groups. Only when the paranoid words were separated from the more general negative words (this study did not include a positive word condition) did group differences in interference emerge (Bentall & Kaney, 1989). In the current study, a comparable emotion effect was not detected between the schizophrenia and the control group. Partially consistent with the findings described by Bentall and Kaney (1989), the current study did detect an emotion effect within the schizophrenia group, specifically this group performed faster in the neutral versus emotional task condition. However, unlike Bentall and Kaney (1989), the current study did not observe an emotion effect in the control group.

In a different study investigating attentional bias to emotionally salient material in individuals with persecutory delusions, it was reported that the persecutory group demonstrated an emotion effect for both positive and negative words (compared to neutral words), and that this effect was larger in the delusion group compared to the control group, whose performance did not differ as a function of word type (Kinderman, 1994). However, this author used negative and positive self-esteem adjectives versus neutral adjectives in their emotional Stroop task. Again, results of the current study are partially consistent in that there was an emotion effect in the schizophrenia group and the

absence of an emotion effect in the control group, however there was no difference in the magnitude of emotion effect between the groups.

The reason(s) for the apparent mix of consistent and inconsistent findings among these studies and the current study are not immediately clear, though it is possible that task differences placed a role. Both Bentall and Kaney (1989) and Kinderman (1994) used a card version of the Stroop task, which provides a less fine grained approach to measuring reaction time compared to the computerized version of the task used in the current study. Task stimuli in the emotion condition also differed significantly among all three studies, with the current study using negative and positive emotion words, Bentall and Kaney employing paranoia and depressive words, and Kinderman using positive and negative self-esteem adjectives. Compared to both of these previous studies, the emotional stimuli used in the current study was of a more general nature and no attempt was made to ensure that emotion words would be personally relevant to the delusion group. Additionally, both of these studies utilized a persecutory delusion group, while the current study used a mixed delusion group.

The combination of these two factors may have been of particular importance in determining the nature of an emotion effect in the current study given previous findings described by Fear and colleagues (1996a). In their study of individuals with delusional disorder (a subset of whom had persecutory delusions), the delusion group as a whole displayed greater interference for threatening words compared to controls (who showed no emotion effect), however individuals within the delusion group with non-persecutory delusions also showed greater interference for other types of emotionally salient words (anxiety and sadness words) compared to controls (Fear, Sharpy, & Healy, 1996a). In a

separate publication utilizing the same sample, it was reported that medication status also had an effect on task performance, in that the unmedicated group showed a greater degree of interference for threat and anxiety valenced words compared to medicated patients with delusional disorder (Fear & Healy, 1996b). Taken together, these prior studies seem to highlight the importance of using words that are not just emotionally salient, but also have self-referent value, a factor which may then differ depending on other features such as delusion subtype and even medication status.

In an investigation of emotional Stroop performance in individuals with schizophrenia who were subdivided based on PANSS symptom ratings, it was hypothesized that severity of negative symptoms would be related to a greater emotion effect for negative words (Demily et al., 2009). Of all of the studies discussed thus far, this one used a task that most closely approximated the one in the current study – a computerized emotional Stroop task containing neutral words and positively and negatively valenced emotion words selected to minimize personal relevance to participants. Though these authors were primarily interested in differences in the negative syndrome patients, they included a positive symptom subgroup and a control group, thus several findings from the current study can be compared to that of Demily et al. (2009). Consistent with findings from the current study showing no difference in the size of emotion effects between the groups, these authors reported that the schizophrenia group (combining positive and negative patients) showed the same degree of interference for emotion words as controls. In this study, the schizophrenia group responded more slowly overall compared to controls on all task conditions (in the current study, this finding was a statistical trend). Demily et al. (2009) also reported that, although both the

schizophrenia group and control group demonstrated an emotion effect (both groups were faster in the neutral condition), there was no significant difference between RT as a function of valence within or between the groups. This finding was partially consistent with that of the current study, which found that while task valence had an impact on overall performance (both groups performed better with positive words compared to negative words), there were no between group differences as a function of valence. Finally, these authors also reported that there was no difference in emotion effect related to severity of either negative or positive symptoms as measured by the PANSS (Demily et al., 2009). In the current study, there was no difference in emotion effect related to delusion-proneness.

So far, the discussion of the emotion effect in the current study has focused on differences within or between participants based on diagnostic groups that categorize them by schizophrenia status. However, throughout this discussion, previous literature that has been referred to frequently employs other approaches to group assignment, namely 1) grouping participants by delusion or positive symptom status; and 2) selecting or grouping participants by delusion subtype (primarily persecutory subtypes). Although diagnostic category was considered a relevant grouping factor in the current study, an alternative method for investigating potential differences in the emotion effect was also used. All participants were administered a measure of delusion-proneness (the PDI) and scores from this measure were entered as a covariate in all analyses in order to explore the possibility that the emotion effect was more closely related to delusion-proneness rather than diagnostic group. This hypothesis was not supported, as the interaction between task condition and PDI total score was not significant in any of the previously

described analyses of emotion effects. Additionally, exploratory analyses investigating whether a particular dimension of delusion-proneness was associated with the emotion effect were not statistically significant for any of the cognitive tasks administered.

Previous research has suggested that investigating cognitive biases in individuals with schizophrenia may mask the presence of putative deficits that are specific to individual symptoms such as delusions (Aleman & David, 2006). These authors have advocated the approach of investigating single symptoms of the disorder in order to determine what factors maintain or even predict those symptoms. Previous research has also suggested that characteristic reasoning and attention biases appear to be related to delusions, and that concurrent processing of emotional stimuli may amplify these biases (Freeman & Garety, 2003). In the current study, this question was addressed by examining whether emotion effects would increase as the severity of delusional proneness increased across all participants. While it was expected that delusion-proneness would be related to the degree of emotion effects on all tasks regardless of diagnostic group, this was not the case. Given the previously discussed finding that the magnitude of emotion effects did not differ between the groups for any of the tasks, the findings with the PDI are not entirely surprising when considering that PDI scores were also higher in the schizophrenia group. In other words, since there a good degree of overlap between diagnostic group and increased delusion-proneness, the two hypotheses were not getting at entirely independent questions. Still, past studies have reported that differences that may not be apparent between diagnostic groups are apparent when considering level of delusion-proneness. For instance, in an investigation of the JTC data-gathering bias, a difference in performance was detected when participants were grouped

by delusion status, but this difference disappeared when participants were grouped by diagnosis (Peters et al., 2007). It was therefore plausible to predict that the PDI total score or perhaps one of the dimension scores from the measure would be more sensitive to differences in performance between the neutral and emotion conditions in each set of cognitive tasks. It is worth noting again that in general, there was little variation in performance between the neutral versus emotional task conditions. Had the predicted emotion effects emerged, the finding that PDI score was not related to degree of emotion effect would be more meaningful. For this reason, though results of the current study provide no direct support for the theory that increased delusion-proneness is uniquely related to a deficit in processing emotional stimuli during cognitive performance (at least not on the tasks employed here), these results should not be considered conclusive.

The lack of the presence of an emotion effect in all tasks except the emotional Stroop task in the schizophrenia group presents a challenge when attempting to fit the current findings with theoretical accounts of cognitive and emotional processes in delusions. Irrespective of the emotional effects, the current study did find overall support for the presence of group differences in basic cognitive task performance, though the group difference in the emotional Stroop task was a statistical trend. These findings add to the established literature describing reasoning and attention biases in individuals with schizophrenia. However, the main aim of the current study was to test hypotheses related to theories of the relationship between cognitive and emotional processing related to delusional thought. For instance, Garety et al. (2007) have suggested that emotion plays a direct role in the development of delusions via the influence of affective processes on cognitive appraisals. Though the current study did not directly assess the role of cognition

or emotion in delusional development, it could be argued that the findings do not support the general idea that emotional processes impact cognitive processes in a different or unique way in individuals with delusions. However, this conclusion fails to account for many alternative explanations for the findings presented here. Though several possible shortcomings of the actual measures have already been discussed, there is the larger issue of the generalizability of laboratory simulations of the presumably complex cognitive and emotional processes that lead an individual to develop and maintain an intricate web of delusional beliefs. It is difficult to design tasks that assess the most relevant thought processes underlying delusions. However, it is encouraging that a growing body of past research has shown specific tasks, such as the JTC task, to be useful in assessing a particular reasoning bias that does appear to be related in some way to the presence of delusions. It is also promising that findings from the current study do suggest that participants in the group comprised primarily of individuals with delusions did not perform as well as healthy controls on the tasks as a whole. The failure to detect larger emotion effects in this study may indicate that the added presence of an emotional component did not hinder cognitive processing on the tasks administered in any appreciable way in individuals with schizophrenia. Alternatively, it may very well be that material must be emotionally salient to delusion content in order for significant effects to emerge, or that emotion interacts with cognition at some other stage or in a different manner than what was assessed in the current study. Therefore, it would be premature to assume that an individual's lack of preferential recall of emotional words related to a psychiatric diagnosis or self-ratings of delusional thought disproves the notion that

cognitive and emotional processes are working together to maintain this individual's delusions.

Several limitations of the current study have been discussed, including potential constraints of the task versions used, effectiveness of the emotion stimuli selected, and methods of grouping participants. Other limitations include those related to demographic features, sample size, and the reliance of self-report ratings on one of the measures. In terms of group composition, gender was unevenly divided in both groups, with males comprising approximately two thirds of each group. The schizophrenia group was not matched to the control group on years of education, though they were matched on the premorbid estimate of intelligence and parental education. Though a power analysis suggested that the sample size (25 participants in each group) was likely sufficient to detect group differences in the current study, there were other limitations imposed by the relatively small number of participants in each group. Given the pattern of results, it may have been informative, as an exploratory analysis, to examine the impact of delusion subtype (e.g., persecutory, grandiose) on performance. Though this information can be gleaned from the PDI, a substantially larger number of participants would be needed in order to get adequate numbers of individuals from each subtype. The use of the PDI could also be considered a limitation, as this measure relies on self-report of individuals from a population that may be hesitant to answer or endorse certain items due to paranoia or other illness factors (e.g., poor insight). However, observer ratings of symptoms in the current study indicate agreement between observed and self-reported symptoms related to delusions. In particular, there was a statistically significant relationship between the SCI-PANSS Positive symptom score (observer-ratings based on a structured interview) and

the self-report total score from the PDI ($r = 0.72$, $p < 0.001$), suggesting considerable overlap between symptoms that were observed and assessed by the experimenter and those that were reported by participants in the schizophrenia group.

Despite these limitations, results of the current study are useful for guiding future research. Taken together with much of the theoretical and applied research that has been reviewed, results of the current study suggest a need for a more thorough evaluation of optimal methods for creating emotional versions of the tasks. Once a reliable method for inducing emotion in healthy controls is determined, this method can be tested in patient groups and then in relation to individual symptoms. It is possible that what constitutes an emotionally salient task in one group is different for another group, and so the possibility of a more fine grained approach to altering stimuli could be explored. Alternatively or in addition, future studies may want to include participant ratings of stimuli from both conditions in order to ensure that neutral stimuli is really perceived as neutral and emotional stimuli as emotional. The use of realistic scenarios to explore emotional salience may also be preferable to more contrived laboratory based manipulations, though this is often time consuming and tends to create added variance from uncontrolled variables. Overall, it seems that future studies using improved methods for increasing emotional salience of task stimuli would better address questions regarding magnitude of emotion effects.

Apart from the findings related to emotion effects, the finding that individuals in the schizophrenia group generally performed more poorly than the control group on the cognitive tasks administered could also inform future research. To date, the line of work investigating the treatment of cognitive deficits in individuals with schizophrenia and/or

delusions is quite new. In a very recent study, it was reported that a brief session of 'reasoning training' was associated with improved performance on the JTC task in individuals with delusions and a diagnosis of schizophrenia (Ross et al., 2009). These authors also reported that, subsequent to reasoning training, some participants reported increased flexibility and decreased conviction of delusional beliefs, though this finding was not statistically significant. Future research should continue to explore the mechanisms underlying the cognitive processes of delusional thought so that more refined approaches to treatment can be developed and tested, as the need to improve the everyday emotional functioning of individuals with delusions is undeniably tied to symptom reduction or relief.

APPENDIX A: PHONE SCREENING FORM (CONTROL GROUP)

PHONE SCREEN FOR CONTROL GROUP

Full Name of Potential Participant:
Phone Number: ( ) - Interviewer Initials:
Date of Phone Screen: / /

“Hi. My name is _____ and I’m calling from the Psychology Department at the University of Central Florida in response to the phone message that you left, indicating interest in our research study. May I ask how you learned about our study?” (USE ANSWER TO DETERMINE WHETHER CONTROL OR SCHIZOPHRENIA PROBAND)

“Before I explain the study, we need to determine whether you are eligible for this particular study. What is your current age? _____ (note: exclude if under 18 or over 60). To see if you are eligible, I will list a series of statements and, at the end of the list, you will say "yes" or "no" to indicate whether you would answer at least one of the items from the list as being true for you. In this way, we will not know which items from the list are true for you, in order to protect your confidentiality. Please think about each item after I read it, but only answer "yes" or "no" after I've read all items. Please answer “no” unless you are fairly sure that an item applies to you. Do you have any questions or concerns about this before I begin the list?

Exclusion List (Only get a "yes" or "no" at the very end of each list – NOT after each item):

- "At some point in my life, I got hit in the head so hard that I blacked out for more than 10 minutes."
- "I've experienced one or more seizures after the age of 5."
- "I've been diagnosed with a stroke, brain tumor, or other serious neurological disorder - like Parkinson’s disease."
- "In the past month, I have used alcohol or drugs to the point that it affected my functioning at school, work, or personal relationships."
- "During at least one point in my life, I received inpatient hospitalization for alcohol or drug dependence."

"Without telling me which item, would you have answered "yes" to at least one item I just listed?" YES / NO (IF YES, skip to below)

"Now we will do the same thing with another list of items. Please remember to wait until the end of the list to indicate whether at least one of them applies to you."

- "I am color blind to some extent."
- "I currently have significant problems with my vision, even when wearing glasses or contacts."
- "I have significant difficulty with moving or feeling the arm or hand that I use for writing."

- "I have been diagnosed with schizophrenia, bipolar disorder, autism, Asperger's disorder, or schizoaffective disorder at some point in my life."

- "I have a family member who I'm biologically related to, who has been diagnosed with schizophrenia or schizoaffective disorder at some point in their life."

"Without telling me which item, would you have answered "yes" to at least one item I just listed?" YES / NO (IF YES, skip to below)

"Now we will do the same thing with one last set of items. Please remember to wait until the end of the list to indicate whether at least one of them applies to you."

- "I have been diagnosed with AIDS, Lupus, congestive heart disease, or insulin-dependent diabetes."

- "I have been diagnosed with dyslexia or another specific learning disability."

- "I have had surgery on my nose or sinuses."

- "English is not the first language that I spoke as a child."

- "I have received electroconvulsive therapy in the past six months."

- "I have been prescribed antipsychotic medication at some point in my life."

"Without telling me which item, would you have answered "yes" to at least one item I just listed?" YES / NO (IF YES, skip to below)

If "**YES**" to any list above – "Thank you for your openness with this procedure. Unfortunately, you do not qualify for this particular study because you endorsed at least one of these factors which could influence your performance on the tasks in our study. We appreciate your time completing this brief phone screen. Do you have any questions I can address?"

IF "**NO**" – "Thanks for going through this list with me. It sounds like you qualify for participation in our study. Can I give you a brief overview of what the study involves, so that you can decide if you'd like to participate?"

"We are conducting a study to examine differences in thinking ability and perception as it relates to a psychiatric disorder called schizophrenia. We are interested in having you participate in a community comparison group so that we can look at differences in your performance with the performance of individuals with schizophrenia and their family members. We hope to gain information that may lead to better treatment or ways to prevent schizophrenia."

"The study will take place in our research laboratory in the Psychology Building on the main campus of the University of Central Florida in east Orlando. You will be provided with detailed directions and free parking in front of the building. During this meeting, we will interview you about your mental and physical health and you will be asked to complete some questionnaires about psychological experiences you may have had. After this interview, we will ask you to complete a series of thinking ability and perception tasks. We would also like to collect a sample of your DNA by swabbing the inside of your cheek with a small brush. All information you

provide will remain strictly confidential. Your name will not be used in any report or presentation. This meeting would last about 3.5 hours. You will be paid by check at the end of the meeting at the rate of $8 for each 30 minutes of participation, so you can expect to be paid approximately $56, although the exact time and amount may vary slightly for each participant.

"Are there any questions or concerns about that I can address for you?"

"Are you willing to participate, with the understanding that you can discontinue participation at any point, for any reason, without penalty?"
IF SO – schedule date and time: _____

"I have a map and directions to send you to help you find our building. Would you prefer that I e-mail, fax, or mail these to you?" (INCLUDE INFORMATION BELOW) - Send our cover letter with appointment date and time, along with map/directions.

APPENDIX B: PHONE SCREENING FORM (SCHIZOPHRENIA GROUP)

PHONE SCREEN FOR SCHIZOPHRENIA GROUP

Full Name of Potential Participant:
Phone Number: ( ) - Interviewer Initials:
Date of Phone Screen: / /

"Hi. My name is _____ and I'm calling from the Psychology Department at the University of Central Florida in response to the phone message that you left, indicating interest in our research study. May I ask how you learned about our study?" (USE ANSWER TO DETERMINE WHETHER CONTROL OR SCHIZOPHRENIA PROBAND)

"Before I explain the study, we need to determine whether you are eligible for this particular study. What is your current age? _____ (Note: exclude if under 18 or over 60).

- Has a doctor told you that have a diagnosis of schizophrenia? YES / NO
- What are the names of the medications that you are currently prescribed (do not need doses – ask participant to look at their prescription bottles if unsure):

_____ _____ _____

_____ _____ _____

(Note: Needs to report a diagnosis of schizophrenia from some type of doctor/psychologist. Also, needs to be currently prescribed some type of antipsychotic medication. Otherwise, explain these criteria and discontinue screen).

To see if you are eligible, I will list a series of statements and, at the end of the list, you will say "yes" or "no" to indicate whether you would answer at least one of the items from the list as being true for you. In this way, we will not know which items from the list are true for you, in order to protect your confidentiality. Please think about each item after I read it, but only answer "yes" or "no" after I've read all items. Please answer "no" unless you are fairly sure that an item applies to you. Do you have any questions or concerns about this before I begin the list?

Exclusion List (Only get a "yes" or "no" at the very end of each list – NOT after each item):

- "At some point in my life, I got hit in the head so hard that I blacked out for more than 10 minutes."
- "I've experienced one or more seizures after the age of 5."
- "I've been diagnosed with a stroke, brain tumor, or other serious neurological disorder - like Parkinson's disease."
- "In the past month, I have used alcohol or drugs to the point that it affected my functioning at school, work, or personal relationships."
- "During at least one point in my life, I received inpatient hospitalization for alcohol or drug dependence."

"Without telling me which item, would you have answered "yes" to at least one item I just listed?" YES / NO (IF YES, skip to below)

"Now we will do the same thing with another list of items. Please remember to wait until the end of the list to indicate whether at least one of them applies to you."

- "I am color blind to some extent."
- "I currently have significant problems with my vision, even when wearing glasses or contacts."
- "I have significant difficulty with moving or feeling the arm or hand that I use for writing."
- "I have received electroconvulsive therapy in the past six months."

"Without telling me which item, would you have answered "yes" to at least one item I just listed?" YES / NO (IF YES, skip to below)

"Now we will do the same thing with one last set of items. Please remember to wait until the end of the list to indicate whether at least one of them applies to you."

- "I have been diagnosed with AIDS, Lupus, congestive heart disease, or insulin-dependent diabetes."
- "I have been diagnosed with dyslexia or another specific learning disability."
- "I have had surgery on my nose or sinuses."
- "English is not the first language that I spoke as a child."

"Without telling me which item, would you have answered "yes" to at least one item I just listed?" YES / NO (IF YES, skip to below)

If "YES" to any list above – "Thank you for your openness with this procedure. Unfortunately, you do not qualify for this particular study because you endorsed at least one of these factors which could influence your performance on the tasks in our study. We appreciate your time completing this brief phone screen. Do you have any questions I can address?"

IF "NO" – "Thanks for going through this list with me. It sounds like you qualify for participation in our study. Can I give you a brief overview of what the study involves, so that you can decide if you'd like to participate?"

"We are conducting a study to examine differences in thinking ability and perception as it relates to schizophrenia. We are interested in having you participate in the group of individuals who have schizophrenia, so that we can compare the performance to individuals without schizophrenia. We hope to gain information that may one day lead to better treatment or ways to prevent schizophrenia."

"The study will take place in our research laboratory in the Psychology Building on the main campus of the University of Central Florida in east Orlando. You will be provided with detailed

directions and free parking in front of the building. During this meeting, we will interview you about your mental and physical health and you will be asked to complete some questionnaires about psychological experiences you may have had. After this interview, we will ask you to complete a series of thinking ability and perception tasks. We would also like to collect a sample of your DNA by swabbing the inside of your cheek with a small brush. All information you provide will remain strictly confidential. Your name will not be used in any report or presentation. This meeting would last about 4 hours. You will be paid by check at the end of the meeting at the rate of $8 for each 30 minutes of participation, so you can expect to be paid approximately $64, although the exact time and amount may vary slightly for each participant.

"Are there any questions or concerns about that I can address for you?"

"Are you willing to participate, with the understanding that you can discontinue participation at any point, for any reason, without penalty?"
IF SO – schedule date and time: _____

"I have a map and directions to send you to help you find our building. Would you prefer that I e-mail, fax, or mail these to you?" (INCLUDE INFORMATION BELOW) - Send our cover letter with appointment date and time, along with map/directions.

APPENDIX C: INFORMED CONSENT FORM

TITLE: Cognitive Functioning in Schizophrenia

Investigator: Diana Orem, M.S., Doctoral Student
Supervisor: Jeffrey S. Bedwell, Ph.D., Assistant Professor,
Department of Psychology, University of Central Florida,
Orlando, FL

CONSENT FORM TO PARTICIPATE IN AN EXPERIMENTAL STUDY

Introduction

You are being invited to participate in the research as titled above. Your participation is entirely voluntary. You may refuse to participate in this study or withdraw your consent at any time without giving reason and without penalty or loss of benefits to which you are otherwise entitled. You may ask to have your information removed from the research records or destroyed. You will be one of approximately 50 participants in this research study.

Purpose

The purpose of this research is to study the relationship between thinking ability/ perception and schizophrenia. We are also interested in the genetic transmission of these factors. A better understanding of these relationships may provide information that leads to better treatment and ways to prevent schizophrenia.

Duration and Location

Your participation is anticipated to last between 4 and 4.5 hours (although this varies by participant) and will take place in the Clinical Cognitive Neuroscience Laboratory (Rm. 137) in the Psychology Building on the main campus of the University of Central Florida (east Orlando).

Procedures

During this study, the following will occur:

1. You will answer questions about basic demographic information.
2. You will participate in a psychological interview about psychological and medical history and current psychological symptoms.
3. You will complete some self-report scales of emotional and psychological experiences.
4. You will complete a series of tasks that measure your smell ability and emotional processing.

Exclusions

There are some criteria or characteristics that may make you ineligible to participate in this study. Each potential participant will be individually evaluated for eligibility through a two step process: 1) the initial phone screen that you've already completed, and 2) an interview and measures during the first part of today's session. If you are excluded at any point during the session, you will be paid for your time spent up to that point.

Early Withdrawal by You or the Investigator
If, during the course of participating in the study, you decide you do not want to continue to participate (for any reason), please inform the investigator or a member of his research team. You will be paid for each 30 minute interval you participated in (rounded to nearest half hour) and will not be penalized in any way for early withdrawal.

Risks and Discomforts
In rare instances, this study may involve mild emotional discomfort due to personal questions asked during the interview or may become frustrated by difficulty thinking ability tasks. You do not have to answer questions which make you feel uncomfortable and you may stop participation at any time.

Benefits
You may not receive any personal benefit from participating in this study besides being paid for your time. The information gathered from this research may lead to better treatments for schizophrenia.

Payment and Costs to Participation
You will not incur any costs due to your participation in this study. You will receive a check for $8 per half hour that you participated (rounded to the nearest half hour) at the end of the research session. The total length of the session is estimated at 4 to 4.5 hours, which translates to a payment between $64 and $72, although this will vary by participant. If you decline to participate during this informed consent procedure, you will not receive payment.

New Findings
You will be given any new information gained during the course of this study that might affect your willingness to continue participation in the study.

Confidentiality
Every effort will be taken to protect your identity. This form, which contains your name, will be kept in a separate secure file cabinet from the rest of your information from the study. Questionnaires and tests will not include your name. You will not be identified in any presentation or publication of this study or its results. Your DNA sample will be stored in a container that only has a random ID# and date written on it. Please note: we may have to notify the proper authorities (without your permission) if you lead us to believe that you are in imminent danger of physically harming yourself or others.

Questions
If you have questions regarding the study, you may call Jeffrey Bedwell, Ph.D. at 407-823-5858 or e-mail him at jbedwell@mail.ucf.edu.

Injury
If you believe you have been injured during participation in this research project, you may file a claim with UCF Environmental Health & Safety, Risk and Insurance Office, P.O. Box 163500, Orlando, FL 32816-3500 (407) 823-6300. The University of Central

Florida is an agency of the State of Florida for purposes of sovereign immunity and the university's and the state's liability for personal injury or property damage is extremely limited under Florida law. Accordingly, the university's and the state's ability to compensate you for any personal injury or property damage suffered during this research project is very limited.

Consent to Participate

My signature below indicates that I agree with the information described above and voluntarily agree to participate in this study. Any questions I have about this study have been clearly answered.

Authorization and Signatures

I am the Research Participant or am authorized to act on behalf of the Research Participant. I have read this Authorization, and I will receive a copy of this Authorization after it is signed.

_____	_____
Signature of Research Participant or Research Participant's Legal Representative*	Date
_____	_____
Printed Name of Research Participant or Research Participant's Legal Representative*	Representative's Relationship to Research Participant

*Please explain Representative's Relationship to Research Participant and include a description of Representative's Authority to act on behalf of Research Participant:

_____

_____

Signature/Printed Name of Person Obtaining Informed Consent Date

APPENDIX D: PETERS ET AL. DELUSIONS INVENTORY

This questionnaire is designed to measure beliefs and vivid mental experiences. We believe that they are much more common than has previously been supposed, and that most people have had some such experiences during their lives.

Please answer the following questions as honestly as you can. There are no right or wrong answers, and there are no trick questions.

Please note that we are NOT interested in experiences people may have had when under the influence of drugs.

IT IS IMPORTANT THAT YOU ANSWER ALL QUESTIONS

For the questions you answer YES to, we are interested in:

(a) how distressing these beliefs or experiences are
(b) how often you think about them
(c) how true you believe them to be.

Below each question, please circle the number which corresponds most closely to how distressing this belief is, how often you think about it, and how much you believe that it is true.

Examples:

Do you ever feel as if people are reading your mind?

(NO) YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

Do you ever feel as if you can read other people's mind?

NO (YES) ↓

If YES:

Not at all distressing 1	(2)	3	4	Very Distressing 5
Hardly ever think about it 1	2	(3)	4	Think about it all the time 5
(Don't believe it's true 1)	2	3	4	Believe it is absolutely true 5

(1) Do you ever feel as if you are under the control of some force or power other than yourself? NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(2) Do you ever feel as if you are a robot or zombie without a will of your own?
NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(3) Do you ever feel as if you are possessed by someone or something else?
NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(4) Do you ever feel as if your feelings or actions are not under your control?
NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(5) Do you ever feel as if someone or something is playing games with your mind?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(6) Do you ever feel as if people seem to drop hints about you or say things with a double meaning? NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(7) Do you ever feel as if things in magazines or on TV were written especially for you?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(8) Do you ever think that everyone is gossiping about you?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(9) Do you ever feel as if some people are not what they seem to be?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(10) Do things around you ever feel unreal, as though it was all part of an experiment?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(11) Do you ever feel as if someone is deliberately trying to harm you?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(12) Do you ever feel as if you are being persecuted in some way?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(13) Do you ever feel as if there is a conspiracy against you?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(14) Do you ever feel as if some organization or institution has it in for you?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(15) Do you ever feel, as if someone or something is watching you?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(16) Do you ever feel as if you have special abilities or powers?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(17) Do you ever feel as if there is a special purpose or mission to your life?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(18) Do you ever feel as if there is a mysterious power working for the good of the world?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(19) Do you ever feel as if you are or destined to be someone very important?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(20) Do you ever feel that you are a very special or unusual person?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(21) Do you ever feel that you are especially close to God?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(22) Do you ever think that people can communicate telepathically?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(23) Do you ever feel as if electrical devices such as computers can influence the way you think? NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(24) Do you ever feel as if there are forces around you which affect you in strange ways?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(25) Do you ever feel as if you have been chosen by God in some way?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(26) Do you believe in the power of witchcraft, voodoo, or the occult?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(27) Are you often worried that your partner may be unfaithful?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(28) Do you ever think that you smell very unusual to other people?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(29) Do you ever feel as if your body is changing in a peculiar way?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(30) Do you ever think that strangers want to have sex with you?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(31) Do you ever feel that you have sinned more than the average person?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(32) Do you ever feel that people look at you oddly because of your appearance?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(33) Do you ever feel as if you had no thoughts in your head at all?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(34) Do you ever feel as if your insides might be rotting?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(35) Do you ever feel as if the world is about to end?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(36) Do your thoughts ever feel alien to you in some way?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(37) Have your thoughts ever been so vivid that you were worried other people would hear them? NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(38) Do you ever feel as if your own thoughts were being echoed back to you?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(39) Do you ever feel as if your thoughts were blocked by someone or something else?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

(40) Do you ever feel as if other people can read your mind?

NO YES ↓

If YES:

Not at all distressing 1	2	3	4	Very Distressing 5
Hardly ever think about it 1	2	3	4	Think about it all the time 5
Don't believe it's true 1	2	3	4	Believe it is absolutely true 5

APPENDIX E: IRB APPROVAL LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407 823-2901, 407 882-2901 or 407 882-2276
www.research.ucf.edu/compliance/irb.html

Notice of Expedited Initial Review and Approval

From **: UCF Institutional Review Board**
FWA00000351, Exp. 5/07/10, IRB00001138

To : **Jeffrey S. Bedwell** and **Kiminobu Sugaya**

Date : **February 14, 2008**

IRB Number: **SBE-08-05420**

Study Title: **Neurocognitive Functioning in Schizophrenia**

Dear Researcher:

Your research protocol noted above was approved by **expedited** review by the UCF IRB Chair on 2/14/2008. **The expiration date is 2/13/2009.** Your study was determined to be minimal risk for human subjects and expeditable per federal regulations, 45 CFR 46.110. The categories for which this study qualifies as expeditable research are as follows:

2. Collection of blood samples by finger stick, heel stick, ear stick, or venipuncture as follows: ***(a)*** Subjects are ***healthy, nonpregnant adults*** who weigh at least 110 pounds; amounts drawn may not exceed 550 ml over 8 weeks; and collection may not occur more frequently than 2 times per week. ***or (b)*** Subjects are ***other adults and children***, considering the age, weight, and health of the subjects the collection procedure; the amount of blood to be collected; and the frequency with which it will be collected. For these subjects, the amount collected may not exceed the lesser of 50 ml or 3 ml per kg over 8 weeks, and collection may not occur more frequently than 2 times per week.

7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

The IRB has approved a **consent procedure which requires participants to sign consent forms.** Use of the approved, stamped consent document(s) is required. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Subjects or their representatives must receive a copy of the consent form(s). All data, which may include signed consent form documents, must be retained in a locked file cabinet for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-

protected computer if electronic information is used. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

To continue this research beyond the expiration date, a Continuing Review Form must be submitted 2 – 4 weeks prior to the expiration date. Advise the IRB if you receive a subpoena for the release of this information, or if a breach of confidentiality occurs. Also report any unanticipated problems or serious adverse events (within 5 working days). Do not make changes to the protocol methodology or consent form before obtaining IRB approval. Changes can be submitted for IRB review using the Addendum/Modification Request Form. An Addendum/Modification Request Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at http://iris.research.ucf.edu .

Failure to provide a continuing review report could lead to study suspension, a loss of funding and/or publication possibilities, or reporting of noncompliance to sponsors or funding agencies. The IRB maintains the authority under 45 CFR 46.110(e) to observe or have a third party observe the consent process and the research.

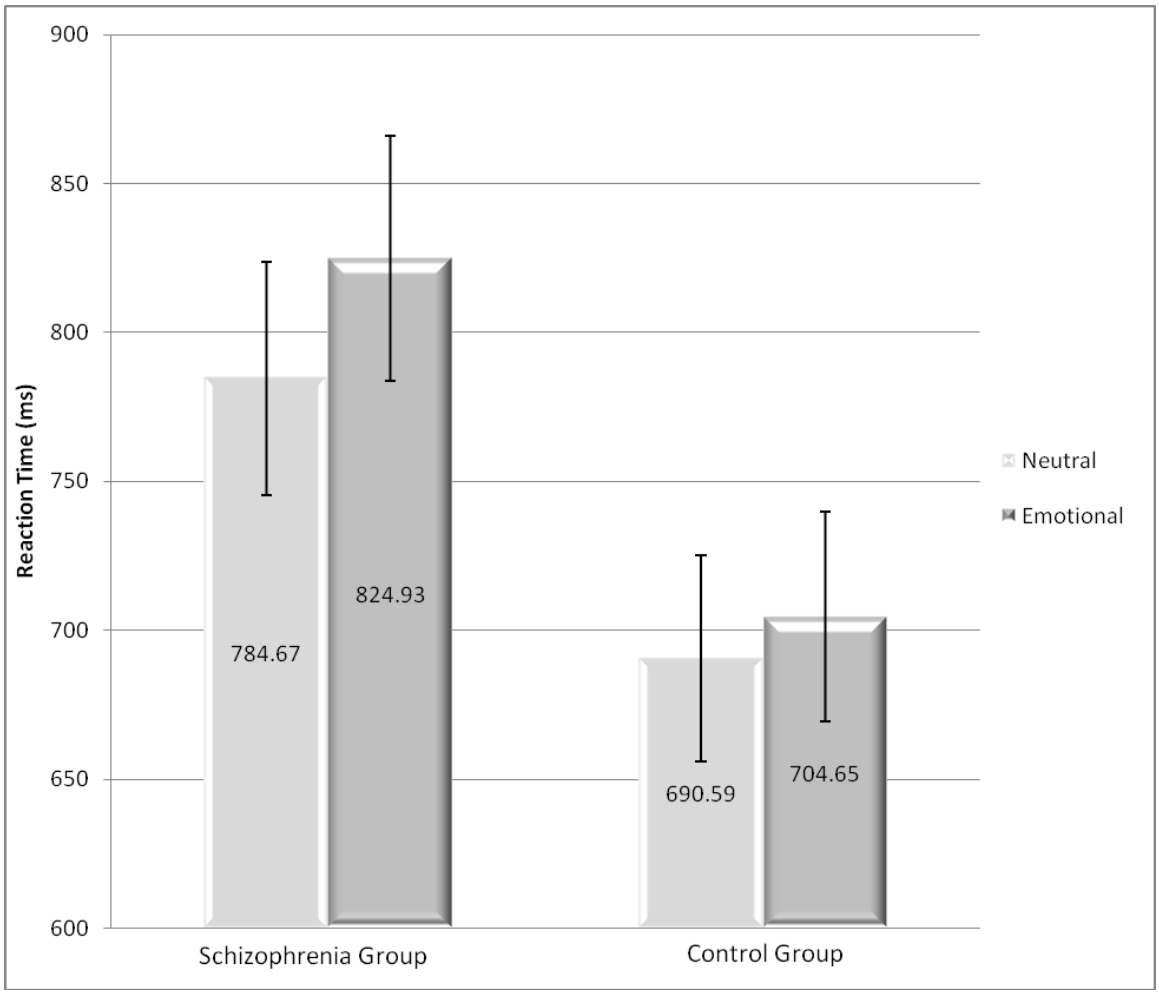
On behalf of Tracy Dietz, Ph.D., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 02/14/2008 04:59:45 PM EST

IRB Coordinator

APPENDIX F: FIGURE

Figure 1. *Comparison of Schizophrenia and Control Group Reaction Times on Neutral and Emotional Conditions of the Emotional Stroop Task*



Schizophrenia group difference: $p = 0.04$*
Control group difference: $p = 0.28$

APPENDIX G: TABLES

Table 1. *Group Differences on Demographic and Clinical Characteristics*

Measure	Schizophrenia group (*n* = 25)	Control group (*n* = 25)
Gender (male)[a]	64%	64%
Age	39.61 (11.92)	39.57 (11.13)
Years of education	12.2 (1.8)**	14.2 (1.9)**
Race: Causcasian[a]	56%	56%
Race: African American[a]	28%	28%
Race: Hispanic[a]	4%	8%
Race: Asian[a]	4%	0%
Race: Mixed/Biracial[a]	8%	8%
WRAT Standard score	97.92 (10.30)	101.84 (9.42)
PDI Total score	185.48 (113.77)**	52.64 (48.64)**
PDI Yes/No score	15.64 (8.79)**	5.84 (4.62)**
PDI Distress score	52.72 (33.75)**	11.64 (13.29)**
PDI Preoccupation score	52.84 (33.24)**	15.52 (15.14)**
PDI Conviction score	64.28 (41.16)**	19.64 (17.54)**
PANSS Composite score	2.28 (6.76)	--
PANSS Positive score	20.36 (5.20)	--
PANSS Negative score	18.08 (4.23)	--
PANSS General score	37.08 (6.91)	--
PANSS Delusions score	4.04 (1.24)	--

*$p < 0.05$; ** $p < 0.001$

Values represent means and standard deviations for all variables except those notated ([a] indicates a percentage).

Table 2. *Cognitive Task Performance: Means and Standard Deviations*

Measure	Schizophrenia group (*n* = 25)	Control group (*n* = 25)
E-Stroop RT: Neutral	784.67 (122.43)	690.59 (119.04)
E-Stroop RT: Emotion	824.93 (127.56)	704.65 (159.77)
E-Stroop RT: Negative words	841.42 (139.91)	808.44 (123.14)
E-Stroop RT: Positive words	714.13 (168.10)	695.17 (153.01)
Word Recall: Neutral	2.72 (1.92)	3.88 (1.69)
Word Recall: Emotion	2.72 (1.67)	4.16 (1.57)
Word Recall: Negative words	1.40 (1.12)	2.00 (1.35)
Word Recall: Positive words	1.28 (1.17)	2.16 (1.57)
JTC: Neutral	6.19 (2.57)	8.57 (1.36)
JTC: Emotion	5.84 (2.82)	8.34 (1.70)

Scores for the emotional Stroop (E-Stroop) task indicate reaction time in each condition in milliseconds. Scores for the word recall task indicate number words recalled. Scores for the JTC task indicate number of trials to reach a decision on that task.

Table 3. *Primary Analyses of Cognitive Task Performance: Mixed ANCOVA Results - Hypothesis 1*

Main Effect of Group	Degrees of freedom	*F* value	*p* value	Effect size (η^2)
E-Stroop Task[a]	(1 ,46)	2.91	0.10†	0.06
Word Recall Task[b]	(1, 46)	7.28	0.01*	0.14
JTC Task[c]	(1, 46)	4.82	0.03*	0.10

N = 50
Mixed ANCOVA variables: IV1 = group (schizophrenia or control); IV2 = task condition (emotional or neutral); covariate = PDI total score; DV[a] = reaction time; DV[b] = words recalled; DV[c] = trials to decision.
Hypothesis 1: Participants in the schizophrenia group will perform more poorly on the cognitive tasks (both conditions combined within each task) compared to the performance of control group.
* $p < 0.05$
†statistical trend (p = 0.10)

Table 4. *Primary Analyses of Cognitive Task Performance: Paired Samples T-tests - Hypothesis 2*

Task & Group	Degrees of freedom	*t* value	*p* value	Effect size (*d*)
E-Stroop: Schizophrenia	(1, 24)	2.19	0.04*	0.44
E-Stroop: Control	(1, 24)	1.10	0.28	0.22
Word Recall: Schizophrenia	(1, 24)	0.00	1.00	< 0.001
Word Recall: Control	(1, 24)	0.55	0.59	0.11
JTC Task: Schizophrenia	(1, 24)	0.99	0.33	0.20
JTC Task: Control	(1, 24)	0.63	0.53	0.12

N = 25
Hypothesis 2: Within each group, there will be a statistically significant emotion effect between task conditions for each set of tasks, indicated by a difference in performance on the emotional compared to neutral task conditions.
* $p < 0.05$
†statistical trend (p = 0.10)

Table 5. *Primary Analyses of Cognitive Task Performance: Mixed ANCOVA Results - Hypothesis 3*

Condition X Group Interaction	Degrees of freedom	*F* value	*p* value	Effect size (η^2)
E-Stroop Task[a]	(1 ,46)	0.01	0.93	0.01
Word Recall Task[b]	(1, 46)	0.98	0.33	0.02
JTC Task[c]	(1, 46)	0.34	0.86	0.001

N = 50
Mixed ANCOVA variables: IV1 = group (schizophrenia or control); IV2 = task condition (emotional or neutral); covariate = PDI total score; DV[a] = reaction time; DV[b] = words recalled; DV[c] = trials to decision.
Hypothesis 3: Participants in the schizophrenia group will demonstrate a larger emotion effect (discrepancy in performance between emotional and neutral task conditions) compared to the performance of control group.
* $p < 0.05$
†statistical trend (p = 0.10)

Table 6. *Primary Analyses of Cognitive Task Performance: Mixed ANCOVA Results - Hypothesis 4*

Condition X PDI Interaction	Degrees of freedom	*F* value	*p* value	Effect size (η^2)
E-Stroop Task[a]	(1 ,46)	2.12	0.15	0.04
Word Recall Task[b]	(1, 46)	0.95	0.33	0.02
JTC Task[c]	(1, 46)	0.62	0.43	0.01

N = 50
Mixed ANCOVA variables: IV1 = group (schizophrenia or control); IV2 = task condition (emotional or neutral); covariate = PDI total score; DV[a] = reaction time; DV[b] = words recalled; DV[c] = trials to decision.
Hypothesis 4: The emotion effect will increase in all participants (regardless of group) as delusion-proneness (measured by PDI total score) increases.
* $p < 0.05$
†statistical trend (p = 0.10)

Table 7. *Exploratory Analyses of Valence: Mixed ANCOVA Results - Emotional Stroop Task*

Main Effects & Interactions	Degrees of freedom	*F* value	*p* value	Effect size (η^2)
Main Effect of Valence	(1 ,46)	7.88	0.007*[a]	0.15
Valence X Group Interaction	(1, 46)	1.83	0.18	0.04
Valence X PDI Interaction	(1, 46)	0.28	0.64	0.01

N = 50
Mixed ANCOVA variables: IV1 = group (schizophrenia or control); IV2 = valence (positive or negative); covariate = PDI total score; DV = RT value.
[a] = statistically significant main effect of valence indicated that participants performed better in the positive (versus negative) condition.
* $p < 0.05$
†statistical trend (p = 0.10)

Table 8. *Exploratory Analyses of Valence: Mixed ANCOVA Results - Word Recall Task*

Main Effects & Interactions	Degrees of freedom	*F* value	*p* value	Effect size (η^2)
Main Effect of Valence	(1 ,46)	1.07	0.31	0.02
Valence X Group Interaction	(1, 46)	0.20	0.90	< 0.001
Valence X PDI Interaction	(1, 46)	1.01	0.32	0.02

N = 50
Mixed ANCOVA variables: IV1 = group (schizophrenia or control); IV2 = valence (positive or negative); covariate = PDI total score; DV = words recalled.
* $p < 0.05$
†statistical trend (p = 0.10)

Table 9. *Exploratory Analyses: Emotional Stroop Task & PDI Dimension Scores Mixed ANCOVA*

Condition X Subscale Interaction	Degrees of freedom	*F* value	*p* value	Effect size (η^2)
Condition X Distress	(1 ,46)	2.55	0.12	0.05
Group X Condition X Distress	(1, 46)	0.08	0.78	0.002
Condition X Preoccupation	(1, 46)	1.54	0.22	0.03
GroupXConditionXPreoccupation	(1, 46)	0.04	0.84	0.001
Condition X Conviction	(1, 46)	1.83	0.18	0.04
Group X Condition X Conviction	(1, 46)	0.02	0.89	< 0.001

Mixed ANCOVA variables: IV1 = group (schizophrenia or control); IV2 = task condition (emotional or neutral); DV = words recalled; covariate = PDI Distress score, or PDI Preoccupation score, or PDI Conviction score.
* $p < 0.05$
†statistical trend (p = 0.10)

Table 10. *Exploratory Analyses: Word Recall Task & PDI Dimension Scores Mixed ANCOVA*

Condition X Subscale Interaction	Degrees of freedom	*F* value	*p* value	Effect size (η^2)
Condition X Distress	(1 ,46)	0.44	0.51	0.009
Group X Condition X Distress	(1, 46)	0.16	0.69	0.003
Condition X Preoccupation	(1, 46)	1.31	0.26	0.03
GroupXConditionXPreoccupation	(1, 46)	0.01	0.91	< 0.001
Condition X Conviction	(1, 46)	1.14	0.30	0.02
Group X Condition X Conviction	(1, 46)	< 0.001	0.99	< 0.001

N = 50
Mixed ANCOVA variables: IV1 = group (schizophrenia or control); IV2 = task condition (emotional or neutral); DV = words recalled; covariate = PDI Distress score, or PDI Preoccupation score, or PDI Conviction score.
* $p < 0.05$
†statistical trend (p = 0.10)

Table 11. *Exploratory Analyses: JTC Task & PDI Dimension Scores Mixed ANCOVA Results*

Condition X Subscale Interaction	Degrees of freedom	*F* value	*p* value	Effect size (η^2)
Condition X Distress	(1 ,46)	0.20	0.66	0.004
Group X Condition X Distress	(1, 46)	0.38	0.54	0.008
Condition X Preoccupation	(1, 46)	0.34	0.56	0.007
GroupXConditionXPreoccupation	(1, 46)	0.12	0.73	0.003
Condition X Conviction	(1, 46)	0.06	0.80	0.001
Group X Condition X Conviction	(1, 46)	0.005	0.95	< 0.001

N = 50
Mixed ANCOVA variables: IV1 = group (schizophrenia or control); IV2 = task condition (emotional or neutral); DV = words recalled; covariate = PDI Distress score, or PDI Preoccupation score, or PDI Conviction score.
* $p < 0.05$
†statistical trend (p = 0.10)

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