2007

The Relationship Between Stroop Task Performance And Delusion-proneness In Non-psychiatric Adults

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THE RELATIONSHIP BETWEEN STROOP TASK PERFORMANCE AND DELUSION-PRONENESS IN NON-PSYCHIATRIC ADULTS

by

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B.S. University of Central Florida, 2005

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science
in the Department of Psychology
in the College of Sciences
at the University of Central Florida
Orlando, Florida

Spring Term
2007

ABSTRACT

Delusions are symptomatic of a number of psychiatric disorders; however, nonpsychiatric adults have also been shown to vary on a propensity toward delusional thought, or "delusion-proneness." The current study examined whether there is a relationship between an individual's degree of delusion proneness (on a continuum) and performance on the Stroop task, a cognitive task thought to measure conflict response monitoring. It was theorized that reduced conflict response monitoring ability may relate to (and perhaps cause) increased delusional propensity.

A total of 35 nonpsychiatric college students completed a measure of delusion-proneness (Peter's et al. Delusion Inventory-21 item version; PDI-21), and a computerized version of the Stroop task with three conditions- congruent, incongruent, and neutral. It was hypothesized that PDI-21 scores would be positively correlated to Stroop interference contrast scores. Results revealed that delusion-proneness showed a statistically significant positive correlation with the Stroop reaction time contrast score, but not the accuracy constrast score, in the incongruent/congruent contrasts.

Our pattern of results suggests that efficiency (i.e. reaction time) of Stroop performance is more sensitive to delusion-proneness, compared to the more gross measure of accuracy. This study appears to be the first to report this relationship across a continuum of delusion-proneness in a nonpsychiatric sample, and overall, the findings suggest that delusion-proneness is related to performance on a behavioral measure of conflict response monitoring and inhibitory control. This research may have implications on treatment interventions used with patients presenting with clinical delusions.

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INTRODUCTION

Delusions as a Clinical Symptom

Delusions, in a general sense, can be defined as false beliefs held by an individual. Researchers in the field of psychology and psychiatry have offered a number of definitions of delusions specific to their respective fields, many of which are still debated over. The psychiatrist and philosopher Karl Jaspers is commonly credited as being the first to formally define the concept of delusions in his book *General Psychopathology*. According to Jaspers (Jaspers, 1913/1997), the three main criteria for a belief to be considered delusional are that the belief is: 1) held with certainty, 2) incorrigible, and 3) impossible or false of content. Jaspers' definition has proven both influential, as well as controversial over the years. One of his contemporaries, Kurt Schnieder, proposed that clinical phenomenon such as delusions should be defined on a descriptive basis, avoiding interpretation and speculation, and attempted to dispose of Jaspers' third criterion in his own definition of delusional perception (cited in Hoff, 2006). Despite criticisms such as these, Jaspers' three part criterion served as the basis for the Diagnostic and Statistical Manual of Mental Disorders, Third Edition (DSM-III-R; American Psychiatric Association, 1987) definition of a delusion as:

> "a false personal belief based on incorrect inference about external reality and firmly sustained in spite of what almost everybody else believes and in spite of what constitutes incontrovertible and obvious proof or evidence to the contrary. The belief is not one ordinarily accepted by other members of the person's culture or subculture (e.g. it is not an article of religious faith)."

This definition has subsequently been criticized for containing inconsistencies, and for lacking clinical relevance in detecting delusions (Spitzer, 1990).

The most recent version of the DSM, the DSM-IV-TR (DSM-IV-TR; American Psychiatric Association, 2000), offers an updated, albeit extremely similar, definition of a delusion. The phrase "a false personal belief" has been changed to simply "a false belief," and the phrase "in spite of" has been replaced with "despite." Although the DSM definition is widely used in both clinical practice and research, it has its share of critics as well, and has been called "ambiguous" and fraught with "internal inconsistencies" (Heinimaa, 2002). Other critics have pointed out that delusions might not necessarily be false beliefs *per se* (Bell, Halligan, & Ellis, 2006; Leeser & O'Donohue, 1999), and 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 his review of the historical and contemporary aspects of the concept of delusions, Paul Hoff suggested that due to the span of the conceptual framework that exists in delusion research since the 19th century, "there will *not be just one* final definition of delusion, adopting only one perspective" (Hoff, 2006). It has however become clear that certain themes repeatedly show up in the literature concerning delusions, including that a belief is: 1) held with great conviction 2) defies rational counter-argument, and 3) dismissed as false or bizarre by members of the same socio-cultural group (Gilleen & David, 2005). Another common shorthand definition commonly seen in the literature is the reference to a delusion as a "pathological belief."

Despite the difficulties and criticism which have surrounded the numerous attempts made to operationally define what exactly constitutes a delusional belief, the presence of delusions have proven to be an important clinical manifestation in certain psychiatric disorders, especially psychotic disorders. According to the DSM-IV-TR, a diagnosis of Delusional Disorder (formally known as "paranoia") requires the presence of at least one nonbizzare delusion for a period of

one month, without the presence of hallucinations or formal thought disorder. Subtypes of delusions include: erotomanic type (another person is in love with the individual), grandiose type (delusion of having some great power or influence), jealous type (delusion that a spouse or lover is unfaithful), persecutory type (belief that one is being conspired against), somatic type (involves bodily functions or sensations), mixed type, and unspecified type. This disorder, which also requires that, apart from the impact of the delusions, an individual's functioning is not markedly impaired, has a relatively low prevalence.

A large focus in the research literature has been directed at the presence of delusions as a hallmark symptom of schizophrenia. Schizophrenia is a psychotic disorder that is characterized by significant disturbances in thought, emotion, and behavior, and although the presence of delusions is not required to meet criteria for schizophrenia, they are very common among those with the disorder. Delusions are classified as a positive symptom, denoting an excess or distortion of normal functioning. Furthermore, the content of an individual's delusions can be categorized as bizarre (e.g. aliens are broadcasting one's thoughts into space) or nonbizzare, and further subdivided by theme. The most common theme is that of persecutory delusions; other common types of delusions include delusions of grandeur, delusions of reference, thought insertion, thought broadcasting, and thought extraction. If delusions are especially implausible and are judged to have no possible basis in reality they are classified as "bizarre," in which case fewer symptoms are required to receive a diagnosis of schizophrenia.

Delusions are also a potential symptom of schizoaffective disorder, which is similar to schizophrenia, but includes additional chronic mood swings. Additionally, disorders such as Alzheimer's, major depressive disorder (MDD) with psychotic features, and bipolar disorder with psychotic features may include delusions as part of the symptom profile. In both major

depressive and bipolar disorder, delusions are commonly defined as either mood-congruent (content of the delusion is entirely consistent with either a depressed or manic mood, such as guilt delusions during depression, or power delusions in a manic mood), or mood-incongruent. In both schizotypal and paranoid personality disorders, overvalued ideas, which may or may not be considered delusional, may be present as well.

Although considerable research exists to validate both the definition of delusions offered by the DSM-IV-TR and the clinical utility of categorizing distinct disorders around the presence of disorders, there remains some degree of imprecision in making diagnoses based on the presence or absence of delusions. As stated in the DSM-IV-TR (2000), "it is often difficult to distinguish between a delusion and an overvalued idea (in which the individual has an unreasonable belief or idea but does not hold it as firmly as is the case with a delusion").

Delusional Thought as a Naturally Occurring Dimension

An alternative way of measuring and conceptualizing of delusions was originally proposed by Strauss in 1969, who suggested that delusions are more like points on a *continuum* of normal functioning, and that the position of these points can be determined by dimensions, such as belief conviction of the delusion (J. S. Strauss, 1969). This idea has often been referred to as the *continuum* hypothesis, which according to Peters and colleagues, fits into the dimensional view of schizophrenia symptoms as a whole (E. R. Peters, Joseph, & Garety, 1999). According to the authors, delusions are "no longer conceptualized as all-or-nothing false beliefs," rather the content of delusions lies on a continuum of normality, as does the conviction with which a delusion is held, and the degree of distress or preoccupation associated with the

delusional thought. Later research has suggested that in addition to delusions, other symptoms of schizophrenia may be viewed as lying on the extreme end of a continuum of functioning, ranging from healthy, through eccentric, to floridly psychotic (Claridge, 1994).

The continuum hypothesis has subsequently been supported and extended upon. For example, Chapman and Chapman (1980) constructed and empirically validated a structured interview, as well as paper and pencil scales (Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994), for measuring psychotic-like experiences in a healthy population based on the view that delusions lie on a continuum ranging from mild to extreme paranoia. van Os and colleagues concluded that Strauss's 1969 observation in clinical samples (psychotic symptoms are actually part of a continuum of experience) could be extended to the general population based on related research with nonpsychotic adults in the community (van Os, Hanssen, Bijl, & Ravelli, 2000). Further work in this area has focused on establishing quantitative measures which take into account both the idea that delusional belief is a matter of degree, rather than a qualitative difference, and that delusional belief is prevalent in a healthy community population (E. R. Peters, Day, McKenna, & Orbach, 1999). This has led to the creation of the Peters et al. Delusions Inventory (PDI), which was designed to measure the delusional propensity, or "delusion-proneness" in nonpsychotic adults (E. R. Peters, Joseph, Day, & Garety, 2004; E. R. Peters, Joseph et al., 1999). This measure (and the short version, the 21-item PDI) has been used in a number of studies and has generated considerable support for the continuum hypothesis (Green, Williams, & Davidson, 2003; Laroi & Van der Linden, 2005; Laroi, Van der Linden, Defruyt, van Os, & Aleman, 2006; Lundberg, Cantor-Graae, Kabakyenga, Rukundo, & Ostergren, 2004; E. R. Peters, Day et al., 1999; E. R. Peters et al., 2004; Verdoux et al., 1998; Warman & Martin, 2006). In a recent study using the abbreviated 21-item PDI, the authors found

that scores from their "deluded" sample (e.g. diagnosed with clinical delusions) overlapped considerably with scores from the healthy control group, with 11 percent of healthy controls scoring higher than the mean of the deluded group (E. R. Peters et al., 2004).

In addition to studying delusions in clinical and healthy community populations, much of the research done in this area has identified a "psychosis-prone," or more specifically a "delusion-prone" population, often for the purpose of testing the continuum hypothesis. Other terms associated with this population, include "schizotypy" and "at-risk for schizophrenia," and individuals from these groups are often said to possess schizotypal personality "traits." A longitudinal study by Chapman and colleagues showed that high scorers (scores of at least 1.96 standard deviations above the mean) on their Perceptual Aberration Scale and/or Magical Ideation Scales exceeded control subjects on rates of psychoses, psychotic relatives, schizotypal symptoms, and psychoticlike experiences at a 10-year follow-up, with high scorers showing a 5.5% rate of reporting these symptoms versus 1.3% of controls (Chapman et al., 1994). Delusion-proneness is not necessary to be considered schizotypal or psychosis-prone; however, those who score high on delusion-proneness are considered to have schizotypal traits (Warman & Martin, 2006).

There are a number of reasons why researchers have targeted the psychosis-prone population for the study of delusions. Individuals in the general population who demonstrate unusual beliefs but do not have active delusions offer investigators a unique way to study delusion formation in the absence of symptoms associated with active delusions in psychotic populations. For example, delusions are often seen in conjunction with other positive psychotic features, such as hallucinations (Laroi & Van der Linden, 2005), which may present a confound when attempting to investigate delusions in isolation. In addition, it has been suggested that

studying this population provides a way to investigate cognitive or thinking biases that might be present *before* clinical delusion formation takes place (Warman & Martin, 2006). This makes it possible to better separate and identify cognitive differences that may be present in delusion-prone individuals. However, while studies of delusion-prone individuals can contribute to investigating the etiology of delusions, this line of research is relatively new and has not clarified etiological mechanisms (Gilleen & David, 2005).

Approaches Toward Understanding Delusional Thought

A number of approaches to studying the etiology of delusions exist, and vary widely from numerous disciplines. For example, Hoff summarized nine broad discipline- specific approaches, such as the 'anthropological' approach, the 'neurobiological' approach, and the 'perceptual' approach, just to name a few (Hoff, 2006). In the past 15 years however, a new approach has recently emerged known as the "cognitive neuropsychiatry" branch of investigating delusions. According to Gilleen and David's recently published review of this area, the goal of this approach is to "construct theories of the normal stages involved in belief-formation, and then show how malfunctions produce characteristic psychopathology" (Gilleen & David, 2005). Areas contributing to the work done in this field include traditional neuropsychological measures of cognitive functions such as reasoning, attention, and memory, as well as newer measures from the areas of neurobiology and functional neuroimaging.

Two areas of interest that have recently converged in this subfield are the attentional approach and the neuroimaging approach. Theories generated by research into attentional biases and/or deficits in delusional individuals have recently been investigated and supported using

functional imaging technologies, such as functional magnetic resonance imaging (fMRI). For example, it has been suggested in the research literature that persecutory delusions may arise in part from a self-serving attributional bias (misattribution of relevant stimuli). In order to investigate this view, Blackwood and colleagues used fMRI to reveal that when deluded individuals performed a cognitive task requiring them to evaluate the self-relevance of certain statements, they showed marked absence in rostral-ventral anterior cingulate activation as compared with controls (Blackwood et al., 2004). Based on previous work determining normal activation patterns in this brain region while performing similar tasks, the authors were able to strengthen existing cognitive theories with evidence from neuroimaging studies by uncovering some of the neurobiological correlates to neuropsychological deficits in deluded individuals with paranoid schizophrenia. Specifically, the authors suggested that hypoactivity in the rostral-ventral or 'emotional' division of the ACC in the deluded group while determining self-relevance suggests that such decisions are made in the presence of impaired self-reflection (leading to misattribution of relevant stimuli), as the rostral-ventral ACC is thought to play a key role in self-reflection (Blackwood et al., 2004).

Cognitive Performance Correlates of Delusional Thoughts in Psychiatric Populations

Research on the clinical correlates of delusions stems largely from research in the area of schizophrenia, since delusions are a prominent feature of the disorder, although important contributions also come from research investigating the presence of delusions in other disorders (e.g. Alzheimer's, depression). At the foundation of almost any research in this area is the finding that individuals with psychotic disorders, specifically schizophrenia, have cognitive

deficits; an observation that has been replicated in hundreds of studies. In one of the most systematic and inclusive synthesis of studies comparing cognitive performance of schizophrenia patients to that of healthy adults, it was reported that on average, healthy adults performed almost one standard deviation higher on a given performance measure than the average individual with schizophrenia (Heinrichs, 2005). In an earlier quantitative review of the area, Heinrichs and Zakzanis reported moderate to large effect sizes ($d > .60$) for all 22 neurocognitive test variables analyzed, and concluded that overall, schizophrenia is characterized by a broadly based cognitive impairment that shows varying degrees of deficit depending on the ability domain tested (e.g. attention versus motor versus memory function; (Heinrichs & Zakzanis, 1998). A brief summary of the existing evidence supporting a relationship between schizophrenia and cognition comes from reviews and meta-analyses of studies in the following areas: studies of chronic schizophrenia patients (Bowie & Harvey, 2005; Heinrichs, 2005; Heinrichs & Zakzanis, 1998), research on individuals during first-episode psychosis (Townsend & Norman, 2004), and research on first-degree relatives of individuals with schizophrenia (Kremen et al., 1994; Niemi, Suvisaari, Tuulio-Henriksson, & Lonnqvist, 2003; Snitz, Macdonald, & Carter, 2006). Further support also stems from a smaller body of work investigating cognitive functioning in individuals showing schizotypy features and individuals identified as delusion-prone, which will be discussed at length.

Despite all of the evidence supporting the relationship between cognitive performance and schizophrenia, there is really no 'cognitive profile' typical of any given person with schizophrenia. Furthermore, as Heinrichs points out, although cognitive effect sizes are large across all studies included in his comprehensive meta-analysis, they are still not large enough to serve as reliable markers of any condition included in the DSM-IV schizophrenia category

(Heinrichs, 2005). Cognitive impairment is not necessary to receive a diagnosis of schizophrenia, and among individuals with schizophrenia, cognitive impairment may range from not present to severe impairment. Obviously, it is reasonable to expect that, as in a healthy population, there exist multiple influences modulating cognitive performance in individuals with schizophrenia, such as the following proposed by Heinrichs (2005): pathophysiology, genes, task content and structure, chronic stress and distress, medication, education, gender, and sociocultural influences. However, even studies that have attempted to control for these variables have not produced any definitive explanation for why some patients show extreme cognitive impairment, while others remain virtually symptom-free in that domain. Addressing the apparent limited sensitivity of cognitive performance to schizophrenia from another angle, it has been proposed that the schizophrenia category is itself *too broad* (Heinrichs, 2004), and that organizing members into more homogenous groups could provide an alternative way to investigate clinical correlates and possible etiologies of specific deficits observed in those subgroups.

In the research literature on cognitive performance and schizophrenia, it is becoming more common to see symptom dimensions of the disorder delineated, and distinct cognitive correlates related to these dimensions specified, as there is increasing evidence that certain symptoms and cognitive deficits seem to cluster around these dimensions (Christensen, Mateer, Williams, & Woodward, 2005; Suhr & Spitznagel, 2001). The most common symptom dimensions described in the research literature are: 1) positive symptoms, typically defined by the presence of hallucinations and delusions, 2) negative symptoms, such as alogia, social withdrawl, and apathy, and 3) disorganized symptoms, including formal thought disorder and inappropriate affect. Although these dimensions and the corresponding tools used to measure the presence of symptoms in each cluster play an important role in reducing the heterogeneity seen

in schizophrenia, some researchers believe they fall short of capturing the complexity of psychotic symptoms observed in any given individual, suggesting that more complex models are needed (Peralta & Cuesta, 1999).

Overall, relating cognitive functioning specifically to one symptom dimension of schizophrenia or another is not easy. Isolating cognitive deficits in delusional individuals with schizophrenia has proved challenging, and to date, researchers have yet to describe a consistent 'cognitive profile' for people with delusions (Simpson & Done, 2004). Some of the problems that have come up along the way include: adequately separating the presence of delusions from other positive symptoms such as hallucinations, identifying delusional patients, the availability of assessment measures for this purpose, and possible interference from psychotropic medication taken by many individuals in the target population. Additionally, it has been suggested that of the three main dimensions of schizophrenia, the cognitive underpinnings of the positive dimension in particular (referred to as the "reality distortion" dimension) remains the *least* clear (Christensen et al., 2005).

Despite some of these difficulties, there is a growing body of research aimed at distinguishing the cognitive correlates of specific symptom dimensions in schizophrenia. In a study investigating differential relationships between positive and negative symptoms and neuropsychological deficits, Berman and colleagues reported that schizophrenia patients presenting with predominately negative symptoms showed a distinct profile on a neuropsychological test reflecting specific cognitive functions (the Wisconsin Card Sorting Test), while positive symptoms (delusions and hallucinations) were associated with poor attention, particularly auditory attention (Berman et al., 1997). In their brief summary of findings in this area, Christensen and colleagues report similar associations between the psychomotor

poverty syndrome (equivocal to the negative domain) and impaired cognitive initiation/generation; the disorganization syndrome and deficient inhibition of inappropriate responses; and the reality distortion syndrome (positive domain) and deficient self-monitoring of thoughts and actions.

In an article by Peters and Garety (2006), the authors investigated the Stroop performance of three groups: a deluded group consisting of psychiatric inpatients scoring in the "moderate severity" range of delusions on the Manchester Scale (a measure of psychiatric symptoms), a non-deluded psychiatric control group, and a non-clincal control group. As expected, the deluded group scored significantly higher than the control group (college students) on the PDI-21. Concerning Stroop performance, the control group was significantly faster and made fewer errors than both the psychiatric groups. This performance difference was found during the baseline condition (when the psychotic group was floridly psychotic) and again during the follow-up condition, during which the deluded group was in remission. Additionally, there was a statistical trend in the small sample for the deluded group to make more errors on the Stroop than the non-deluded psychiatric group.

Other studies investigating cognitive differences in delusional individuals have reported the presence of problems in encoding and semantic memory (Magaro, 1981; McKenna, 1991; Saccuzzo & Miller, 1977), difficulties solving analogical reasoning tasks (Simpson & Done, 2004), displaying a 'jumping to conclusions bias' (Garety, Hemsley, & Wessely, 1991; Moritz & Woodward, 2005), and showing a cognitive bias against disconfirmatory evidence (Woodward, Moritz, Cuttler, & Whitman, 2006). Not all studies in this area have reported differences in cognitive performance as a function of symptom dimension or presence of delusions, with some studies failing to find any correlation between delusions and cognitive functioning (Bilder,

Mukherjee, Rieder, & Pandurangi, 1985). Bilder and colleagues did report that the negative and disorganized symptom dimensions were selectively associated with neuropsychological impairment in their sample of schizophrenia patients, but not the positive symptom cluster. Johnstone and colleagues reported similar findings. Although they did report an association between the delusion/hallucination factor and impaired recognition memory, they reported a much more pronounced cognitive deficit to be mainly associated with negative symptoms, and to a lesser degree, disorganized symptoms (Johnstone & Frith, 1996).

It should be pointed out that there are some issues that preclude direct comparison among many of these studies; the most relevant being methodological differences in measuring delusions. As opposed to using scales which are pure measures of delusions, the majority of studies in this area measure delusions in the context of the larger concept of positive symptoms, in some cases combining both symptoms of delusions and hallucinations, and in other cases measuring delusions based on a subset of items endorsed as part of larger measures designed to assess and differentiate between positive and negative symptoms, such as global scores on the Scale for the Assessment of Negative/Positive Symptoms (SANS, SAPS) or the Positive and Negative Syndrome Scale (PANSS). Methods such as these may not be ideal for isolating the concept of delusional thought, or for that matter, for correlating delusions to specific measures of cognitive performance. Authors in favor of using techniques that delineate the precise domains of delusions argue that in the absence of such precision, "the links between symptoms, neurobiology, and cognition will remain clouded by influences of other clinical phenomena" (Kimhy, Goetz, Yale, Corcoran, & Malaspina, 2005).

Cognitive Performance Correlates of Delusion/Psychosis-Proneness in the Community

In an effort to focus on the concept of delusional thought processes, while eliminating some confounds associated with studying schizophrenia patients, a body of research has formed that centers on measuring delusion-proneness. This line of research generally follows the assumption that those who are delusion-prone perform similarly on measures of cognitive functioning to individuals who have delusions, though sometimes to an attenuated degree. For example, the jumping to conclusions (JTC) reasoning bias (gathering minimal data when making overconfident probabilistic judgments) originally described in a psychotic population has subsequently been observed in delusion-prone individuals (Colbert & Peters, 2002; Linney, Peters, & Ayton, 1998; McKay, Langdon, & Coltheart, 2006). Colbert and Peters reported that, in a sample of healthy adults, those who scored high (in the top 25%) on the PDI-21 scored significantly higher on the Need for Closure Scale (a measure of decisiveness and aversion toward ambiguity) and on a measure of the JTC reasoning bias than individuals with low scores (in the bottom 25%) on the PDI-21. Delusion-prone individuals also demonstrate response latencies when processing angry facial expressions, which may be due to a selective attention bias for threat-related stimuli (Green, Williams, & Davidson, 2001). The authors of this study used the PDI-21 as a measure of delusion-proneness in healthy adults and reported that individuals who scored high (above the median split score) on the PDI-21 took significantly longer to process angry facial expressions, as compared to low scorers (below the median split score).

In a series of recent studies, a cognitive bias against disconfirmatory evidence (BADE) has been demonstrated in deluded schizophrenia patients (Woodward et al., 2006), as well as delusion-prone college students who scored high on a measure of schizotypy traits (Buchy,

Woodward, & Liotti, 2007; Woodward, Buchy, Moritz, & Liotti, 2007). The task used in these studies measured a participant's willingness to endorse alternate explanations for hypothetical events in the face of new evidence which disconfirms initial interpretations. In the two studies produced based on a sample of nonpsychiatric adults, greater BADE was reported to be associated with higher scores on the Schizotypy Personality Questionniare (SPQ), and a factor analysis revealed that the delusion-content subscales of the SPQ correlated with levels of integration of disconfirmatory evidence. The authors interpreted this finding as suggestive of a possible contribution of a BADE to delusional ideation (Woodward et al., 2007).

On cognitive tasks that reflect other domains of cognitive functioning, specifically executive function and attention, hypothetically psychosis-prone college students may display specific deficits. Suhr reported that in this population, where psychosis-proneness was assessed using Chapman et al.'s Perceptual Aberration Scale and Magical Ideation Scale, high scorers (at least two standard deviations above the group mean) performed significantly worse on two measures of inhibitory control (Wisconsin Card Sorting Test and the Stroop Incongruent condition- card version) compared to a group scoring in the normal range (within 0.5 standard deviations of the group mean) on the Chapman scales (Suhr, 1997). The author concluded that these findings are consistent with a model suggesting that executive dysfunction in the frontal system of the brain is likely present before schizophrenia-related illness onset, and exists in those vulnerable to development of schizophrenia or related psychotic disorders. In a study of adolescents with clinical high-risk of developing schizophrenia, the high-risk individuals, who all displayed attenuated positive schizophrenia-like symptoms, showed significantly greater cognitive impairments in the executive functioning/working memory and verbal memory dimensions, as well as an overall cognitive deficit, as compared to healthy controls (Lencz et al.,

2006). However, neither of these studies included a measure that specifically measured delusional proneness.

Neurobiological Correlates of Delusional Thoughts

Attempting to link symptoms of psychopathology to putative neurobiological mechanisms has been called "one of the greatest challenges of psychiatry" (Kimhy et al., 2005). There are a number of challenges to undertaking research of this nature; some of the same confounds (i.e. medication effects, chronic hospitalization, heterogeneity of the disorder) and methodological issues (i.e. the use of measures that are not specific enough to uniquely capture the construct of interest) that make it difficult to investigate the neurobiological correlates of cognitive deficits in schizophrenia also present challenges to studying neurobiological correlates of delusional thoughts. To date, investigations using global ratings of positive symptoms in persons with schizophrenia have been somewhat inconclusive in regards to which brain regions correlate with positive symptoms overall, although the anterior cingulate and adjoining medial prefrontal cortex do appear to play an important role in delusions (Kimhy et al., 2005). For example, Sabri and colleagues reported that hypoperfusion in rCBF patterns in the cingulate, left thalamic, left frontal, and left temporal regions of neuroleptic-free schizophrenia patients correlated with the positive symptoms of delusions, hallucinations, and distrust, while other positive symptoms (formal thought disorder, which is more commonly categorized as a disorganized symptom, and grandiosity) showed the opposite pattern, that is hyperperfusion, in frontal, cingulate, and left parietal regions (Sabri et al., 1997). In a study by Lahti and colleagues, reality distortion (delusions/hallucinations) and disorganized symptoms were positively

correlated to rCBF in the left inferior frontal cortex and anterior cingulate cortex (ACC), and negatively correlated with rCBF in the hippocampus/parahippocampus. However, the assessment of these symptoms was limited to three items on the Brief Psychiatric Rating Scale (BPRS) (Lahti et al., 2006). A similar study, which also utilized PET scanning and the ROI method, reported that delusional ideation (as measured by the BPRS) was associated with decreased activity in the hippocampus, and both the delusional and negative symptom clusters were related to reduced activity in the anterior cingulum and medial frontal gyrus in unmedicated schizophrenia patients (Schroder et al., 1996).

Another study reported that in schizophrenia patients, the delusion/hallucination factor of the PANSS was correlated with a decrease in rCBF in the left orbitofrontal region, coupled with an increase in the right lateral temporal region. However, this study used a region of interest (ROI) method to identify potential brain regions associated with symptom dimensions, therefore other brain regions not included in the analysis (e.g. ACC) could have been highly relevant (Kawasaki et al., 1996). A study which used single photon emission computed tomography (SPECT) scanning and the PANSS with schizophrenia patients reported no significant correlations between positive symptoms and any of the brain regions identified by the authors using the ROI method, which included 6 brain regions in each hemisphere, but did not include the ACC (Min, An, Jon, & Lee, 1999). In a different SPECT study which also used the PANSS, the authors reported that the delusion dimension in particular was associated with hypoperfusion in the anterior cingulate cortex in their sample of schizophrenia patients (Erkwoh, Sabri, Steinmeyer, Bull, & Sass, 1997). Other findings in this area include those of Kaplan and colleagues, who reported that the reality distortion (positive) syndrome correlated positively with

left temporal activity; as well as Klemm and colleagues' finding that left temporal hypoperfusion correlates with positive symptoms of schizophrenia (Kaplan et al., 1993; Klemm et al., 1996).

It is evident from this brief review of the literature in this area that some areas are inconsistently found to be related to positive symptoms, while other areas are more consistently found when specifically examined. Obviously, different methods of scanning technology, such as PET versus SPECT versus fMRI, as well as advances in scanning technology have contributed to this; varied methods of assessing and categorizing positive symptoms play a role as well. What these studies do have in common is that, in the bulk of studies that adequately separated out the delusion factor and included the ACC as a ROI, reduced activity in the ACC was reported to be related to the presence of delusions.

Although the presence of delusions is often studied in the context of schizophrenia, delusions appear in a number of other disorders, including Alzheimer's disease. As in schizophrenia research, Alzheimer's researchers are searching for the neural basis of psychotic symptoms (the presence of delusions and/or hallucinations) that sometimes accompany the disease. In a study using SPECT analysis, psychotic patients with Alzheimer's (all had delusions, and half had hallucinations) showed significant hypoperfusion in the dorsolateral prefrontal cortex, left anterior cingulate cortex, ventral striatum, pulvinar, and dorsolateral parietal cortex. The authors concluded that the decrease of activation detected in the right motor, left prefrontal, and cingulate regions support a defect in motor planning and cognitive executive function, as well as the cingulate attentional system (Mega et al., 2000). In another study looking at PET scans of delusional Alzheimer's patients, the authors reported that severity of delusions was associated with hypometabolism in prefrontal and anterior cingulate regions (Sultzer et al., 2003). Other studies of Alzheimer's patients with specific types of delusions (i.e. content

specific, misidentification) have reported similar findings of hypometabolism in the prefrontal cortex (Staff et al., 2000) and anterior cingulate regions (Mentis et al., 1995). In a study using fMRI, Nakano and colleagues reported significantly decreased perfusion in the prefrontal cortex, and anterior cingulate gyri, the right inferior to middle temporal cortices, and the right parietal cortex of Alzheimer's patients with delusions relative to those without delusions (Nakano, Yamashita, Matsuda, Kodama, & Yamada, 2006).

Delusions and hallucinations also appear in 15-20% individuals experiencing a major depressive episode (Johnson, Horwath, & Weissman, 1991). In a study comparing brain activity in psychotic depressed patients, nonpsychotic depressed patients, and controls, Gonul and colleagues reported that both groups of depressed patients showed decreased activity in the superior frontal cortex bilaterally, and in the left ACC, as compared with healthy controls (Gonul, Kula, Bilgin, Tutus, & Oguz, 2004). In another recent study investigating patients with MDD who reported psychotic symptoms (delusions and/or hallucinations) during a major depressive episode, it was reported that these patients displayed reduced activity, as measured by rCBF, in the left anterior cingulate cortex relative to healthy adults and non-psychotic depressed patients (Skaf et al., 2002).

Prospective studies of individuals at high-risk for developing schizophrenia are unique in that they allow the opportunity to determine whether brain abnormalities predate the development of schizophrenia and have the potential to identify those who have the greatest chance of developing the disorder. In one such study, Whalley and colleagues (2006) used fMRI to investigate neural abnormalities in individuals at high risk for developing schizophrenia (those with at least two relatives with the disorder) during performance on a cognitive task (a sentence completion task). The authors reported that reduced functioning in the ACC and lingual gyrus

were the only regions found to differ significantly between the high-risk group who subsequently developed schizophrenia and three other groups: those at high-risk with psychotic symptoms who did not develop the disorder, those in the high-risk group without psychotic symptoms, and a control group. Other brain regions in the parietal lobe were reported to be hyperactive in the high risk group that developed schizophrenia compared to controls, but did not differentiate high risk individuals who later developed schizophrenia from those who did not, suggesting that the finding concerning the ACC and lingual regions may be the most useful for making comparisons in clinical settings. As many individuals with schizophrenia experience delusions at some point in their illness, this study provides indirect evidence that decreased ACC functioning may occur before the onset of clinical delusions in persons with schizophrenia.

Taken together with the schizophrenia and Alzheimer's studies, these studies provide compelling evidence to look toward specific brain regions, particularly the ACC and also DLPFC, when examining the neurobiological correlates of delusions.

The Role of the Anterior Cingulate Cortex in Cognition

The involvement of the anterior cingulate cortex (ACC) in a variety of cognitive and emotional tasks has been established by numerous functional neuroimaging studies. The typical paradigm for studies in this area usually involve having an individual perform a cognitive task while undergoing fMRI or PET scans, and then examining the brain activity response pattern. Early studies using this type of technology first differentiated the function of the anterior cingulate cortex from the posterior cingulate cortex. The anterior part is considered to specialize in 'executive' functions such as attention to action, while the posterior part is thought to play a

more critical role in monitoring sensory events and behavior in the service of spatial orientation and memory function (Vogt, Finch, & Olson, 1992).

Another important distinction that has been described in the literature on ACC function is that cognitive information is processed separately (by a 'dorsal-cognitive' division) from emotional information ('rostral-ventral affective' division). Support for this notion comes from meta-analyses of studies showing that the dorsal region of the ACC is activated during cognitively demanding tasks, such as the Color Stroop task (which involves inhibiting prepotent responses), divided and selective attention tasks, and working memory tasks (Bush, Luu, & Posner, 2000). The authors describe the cognitive subdivision as being part of a "distributed attentional network," which has interconnections to areas in the lateral prefrontal cortex, parietal cortex, and motor areas (Bush et al., 2000; Devinsky, Morrell, & Vogt, 1995). The primary functions commonly attributed to the dorsal-cognitive division of the ACC include modulation of attention/executive functions by influencing response selection, monitoring competition, error detection, and anticipation of cognitively demanding tasks.

Different theories exist regarding the specific role the ACC plays in different cognitive functions. For example, one theory often referred to as the 'error detection' theory proposes that the ACC is critical in monitoring and detecting when errors have been made during cognitive-behavioral tasks. Most of the support for this theory comes from electrophysiological studies which measured error-related negativity (ERN) on the scalp in individuals performing a task requiring error detection, and reported increased activity in the ACC and areas in the prefrontal cortex (Falkenstein, Hohnsbein, Hoormann, & Blanke, 1991; Gehring & Knight, 2000). Some researchers have argued however, that the strategic role of the ACC proposed in the error-detection theory is not entirely accurate. An alternative theory supports an evaluative role of the

cognitive division of the ACC (ACcd) in the on-line detection of processing conflicts, known as the 'competition monitoring hypothesis' (Carter, Botvinick, & Cohen, 1999; Carter et al., 2000). The ACcd's involvement in monitoring response conflict (i.e. the activation of two conflicting responses) rather than simply detecting errors is emphasized according to this theory (Botvinick, Cohen, & Carter, 2004; Kerns et al., 2005). Despite the discrepancies in these and other theories, the ACC clearly plays some role in a larger network responsible for modulating cognitive performance on tasks requiring selective attention, and serves a specific role in modulating the ability to deal with the increased potential for error related to conflicting response selection.

Stroop Test Behavioral Performance as a Proxy for Anterior Cingulate Cortex Functioning

Seventy years of research has firmly established the Stroop task as one of the most widely used neuropsychological measures of cognitive performance, specifically selective attention ability. During the task, an individual is presented with a color word, such as the word 'red' written in either red ink ('congruent' condition) or ink of a different color. When seeing the word 'red' presented in blue ink, for example, the automatic response is to read the word, whereas stating the color of the ink requires suppression of the automatic reading response, thus producing interference during what is called the 'incongruent' condition of the task. An additional neutral condition is the presentation of a neutral stimulus, such as a red rectangle, and the individual simply states the color presented. Although different variants of the task exist, the basic premise is that response conflict is created between color naming and the habitual response of word reading, producing a robust and reliable effect, referred to as the "Stroop effect" (Henik & Salo, 2004).

There are a few different indices of Stroop performance, the most commonly reported being the 'interference effect.' This effect is typically measured by subtracting reaction time (RT) of responding in the neutral trials from RT in the incongruent trials. Another index of Stroop performance that is often reported is Stroop facilitation (neutral RTs minus congruent RTs), which is a measure of how much faster an individual is able to respond in the congruent condition versus the neutral condition. It is also possible, using the computer version of the task, to calculate error rates and to omit errors for single words when calculating RTs. The majority of Stroop studies in the past 15 years have utilized the computerized single-trial version of the task, although the traditional card version is still used for both clinical assessment and research.

When performing the Stroop task, healthy controls demonstrate longer RTs during incongruent trials of the task relative to the neutral and congruent trials. The slowed performance demonstrated on the incongruent trials is generally interpreted as reflecting additional processing time needed to overcome the interference (Gruber, Rogowska, Holcomb, Soraci, & Yurgelun-Todd, 2002), and has been shown to be a reliable and robust phenomenon (MacLeod, 1991). In addition to measuring selective attention, which plays a critical role in guiding attention away from task-unrelated stimuli to task-related stimuli (Leung, Skudlarski, Gatenby, Peterson, & Gore, 2000), researchers have suggested that the Stroop task also taps into response inhibition, as the task requires active inhibition of a habitual response in favor of a more voluntary response (Gruber et al., 2002). On a more basic level, the Stroop task also measures simple focal attention, and the ability to maintain an instruction set (Henik & Salo, 2004).

Neurobiological Correlates of Stroop Performance

The Stroop task has been widely used as a neuropsychological screening instrument for the detection of frontal/executive brain dysfunction for quite some time, a proposition originally suggested by Perret (1974). In following with an overall trend in the cognitive neuroscience research literature of investigating the neural substrates of higher cognitive functions using brain imaging techniques, a subfield in the Stroop literature has recently emerged which aims to identify the specific brain regions and cortical networks underlying performance on the task. In one of the first studies of its kind, Pardo and colleagues reported robust activation in the anterior cingulate cortex during the Stroop task (especially in the incongruent condition), and suggested that the ACC is the most relevant brain region involved in Stroop performance, using PET technology (Pardo, Pardo, Janer, & Raichle, 1990). Besides the ACC, the authors also noted activations in the following areas: left premotor cortex, left postcentral cortex, left putamen, supplementary motor area, right superior temporal gyrus, and bilateral peristriate corticies. Subsequent work using PET imaging has supported the central role of the ACC in Stroop performance (Bench et al., 1993; Carter, Mintun, & Cohen, 1995; Taylor, Kornblum, Minoshima, Oliver, & Koeppe, 1994). However, there are some inconsistencies among these investigations. For example, not all of the studies reported activations in the same brain regions. For instance, compare the findings described by Pardo and colleagues to that of Carter and colleagues, who reported activations (using PET) in the frontal polar cortex, the inferior parietal lobule, the thalamus, and the lingual gyrus, as well as in the ACC (Carter et al., 1995). It should also be noted that a caveat to studies using PET and neuroimaging techniques in general is that differences in experimental treatment parameters (Bench et al., 1993), as well as differences in tomography resolution and changing technologies, may alter outcomes.

Studies using fMRI to uncover neural substrates underlying the Stroop effect have produced results similar to those using PET studies. Increased signal intensity in the ACC during the interference condition relative to the neutral condition has been reported by a number of investigators (Brown et al., 1999; Bush et al., 2000; Bush et al., 1998; Carter et al., 2000; Gruber et al., 2002; Leung et al., 2000). These investigations and others have also implicated a wide number of areas in the prefrontal cortex (PFC), including the dorsolateral prefrontal cortex (DLPFC) and associated regions, as playing a role in attentional processes necessary to perform the Stroop task (Banich et al., 2000; Fan, Flombaum, McCandliss, Thomas, & Posner, 2003; MacDonald, Cohen, Stenger, & Carter, 2000; van Veen & Carter, 2005). Converging evidence from both PET and fMRI neuroimaging studies provide a compelling case for the ACC's central involvement in an attentional network in the brain recruited when performing the Stroop.

Collectively the work done in this area, although not entirely consistent, has created a bridge whereby the Stroop task is viewed as a behavioral proxy for investigating the functioning of the ACC/PFC attentional network. In addition to the Stroop's utility in investigating the functional anatomy of selective attention in healthy individuals, researchers have pointed out that "given recent interest regarding the role of the ACC in the pathophysiology of neuropsychiatric disorders, our results suggest that the Stroop task can serve as a reliable neurobehavioral probe for this region"(Carter et al., 1995).

Stroop Performance and Related Neurobiology in Schizophrenia

The association between schizophrenia and cognitive deficits has prompted many researchers in this area to employ the Stroop task, specifically when investigating attention

performance in individuals with schizophrenia. Attention pathology is indeed one of the most clinically apparent aspects of the psychopathology of schizophrenia (Braff, 1993). Patients with schizophrenia generally show a different performance profile on the Stroop as compared to healthy controls. In a recent review of schizophrenia and the Stroop effect, the authors summarize this body of work, concluding that: 1) patients with schizophrenia tend to show an increase in incongruent error rates, although this phenomenon may be dependent on the length of the intertrial intervals (measured in milliseconds), 2) patients show increased facilitation on the computerized Stroop relative to normal controls, while interference effects are comparable to controls, 3) performance on the computerized single-trial version of the Stroop task is not the same as performance on the card version, as schizophrenia patients generally do show increased interference compared to controls on the card version, 4) at present, there is not sufficient research clarifying the relationship between schizophrenia symptomology and the Stroop effect, and 5) imaging studies suggest that a network of neural structures, including the anterior attentional network, is probably dysfunctional in individuals with schizophrenia (Henik & Salo, 2004).

Abnormal ACC activation has been reported in patients with schizophrenia both at rest and during the single-trial Stroop task (Carter, Mintun, Nichols, & Cohen, 1997; Nordahl et al., 2001; Yucel et al., 2002), along with significant correlations between increased incongruent error rates and decreased ACC metabolism. Carter and colleagues reported that patients with schizophrenia had a higher frequency of errors during the incongruent condition of the Stroop task as compared with a control group of healthy adults, an indication of attentional dysfunction in the patients (Carter et al., 1997). During this task, patients underwent a PET scan, which revealed that they displayed significantly less anterior cingulate gyrus activation during the

incongruent condition as compared to controls. In addition, a number of studies using various cognitive tasks including the Stroop, as well as tasks measuring emotional perception, have reported structural and functional abnormalities in both the DLPFC and ACC patients with schizophrenia (Phillips, Drevets, Rauch, & Lane, 2003).

In an fMRI study comparing ACC activation during the Stroop task in schizophrenia patients versus healthy controls, Kerns and colleagues reported that the schizophrenia patients displayed reduced conflict and error-related activity in the ACC along with reduced trial-to-trial adjustments as compared to controls. The authors suggested that in the patient group, impaired conflict monitoring in the ACC may play a role in contributing to cognitive deficits (Kerns et al., 2005). In another study that compared event-related brain potentials (ERP) of schizophrenia patients and healthy controls performing the Stroop task, patients displayed significantly attenuated amplitude of error-related negativity (ERN) suggestive of dysfunction in the anterior cingulate gyrus and DLPFC (Alain, McNeely, He, Christensen, & West, 2002).

Current Research Aims and Hypothesis

Given the widespread use of the Stroop task as a proxy for measuring ACC function, as well as the evidence that schizophrenia patients and patients with other disorders involving delusions have reduced ACC activity, the aim of the current research is to study ACC activity using the Stroop task in *delusion-prone* individuals. Based on converging evidence, it appears as though individuals experiencing delusions over a range of disorders, such as schizophrenia, depression, and Alzheimer's, may have certain neurobiological differences as compared to healthy controls. A review of the literature in this area reveals that the precise nature and location

of the neurobiological substrates of delusional thought remains unclear. However promising leads include areas in the prefrontal cortex and the ACC. Dysfunction of the ACC appears to be particularly involved with delusional symptoms for a number of reasons. First, among the studies that attempted to isolate delusional thoughts from other positive symptoms, and among the studies that included the ACC in their investigation, the finding of reduced ACC activity related to delusional symptoms is largely consistent, regardless of the disorder. Second, the central role of the ACC in cognitive processes demanding attention and the ability to deal with increased potential for error related to conflicting response selection make it a theoretically salient area to study in the context of delusions. This theory stems from the idea that reduced capacity for monitoring errors related to discrepancies between internally generated thoughts and external reality may contribute to the formation of delusions. Last, the availability of behavioral measures of ACC function, namely the Stroop task, provide a reliable and practical method for isolating and investigating this construct.

The problem with the existing literature investigating the neurobiological and/or cognitive correlates of delusional thought is that a number of confounding factors often cloud interpretation. One broad confounding factor is the problem of the heterogenity inherent in defining and measuring several of our constructs of interest. To address this, we will narrow down the heterogeneous "psychotic symptoms" realm by focusing on delusional symptoms, specifically proneness toward delusional thought. In addition, we will use a well established task (Stroop) to focus on a specific subset of cognitive functioning: selective attention and response inhibition. The Stroop has also been reliably associated as a task recruiting the ACC, which has been shown to be dysfunctional in psychiatric populations experiencing delusions. By using this

focused approach, we hope to better understand the relationship between ACC functioning and delusional-proneness.

In order to examine the relationship between delusional thought and ACC functioning more directly, the current study will focus on healthy adults with a naturally occurring dimension of delusional-proneness. As propensity does vary among healthy adults, it would be informative to investigate whether this is related to variation in performance on our proxy of ACC functioning (the Stroop task). It does not appear that previous research has related the continuum of delusional propensity in healthy adults to a behavioral measure of ACC functioning. Furthermore, investigating the cognitive correlates of delusions using a continuous, correlational approach can provide information about the shape of this relationship (e.g. linear versus nonlinear trends).

A better understanding of the naturally occurring relationship between ACC function and delusional propensity in a nonpsychiatric population will inform the clinical literature. While the current study design cannot address causality, this relationship may prompt investigation to explore the use of the ACC as a marker for treatment efficacy in psychiatric disorders that include delusional symptoms. For example, investigators may use ACC activity levels (e.g. directly via fMRI, or indirectly via Stroop behavioral performance) as a more sensitive marker of subtle changes in delusional propensity resulting from treatment. A better understanding of the natural continuum of this relationship can certainly inform such efforts.

We predict that in a healthy adult population, there will be a relationship between delusion-proneness (as measured by the PDI-21) and performance on a behavioral measure of ACC functioning (the Stroop Test). We expect that a stepwise regression will be statistically significant, which will include both number of errors and reaction time on the Stroop

congruent/incongruent contrast (see Methods for description) to predict PDI-21 total raw score. We expect that the effect size for the reaction time predictor will be greater than the accuracy predictor, and that there will be a positive relationship between increased errors and reaction time with increased PDI-21 score. We expect that this relationship will be best explained by an exponential curve, with an exponential increase in Stroop interference measures related to increasing levels of delusion-proneness.

METHODS

Phase I

Participants for Phase I

Participants for Phase I of this study consisted of 920 undergraduate students at the University of Central Florida (UCF) who were currently enrolled in Psychology courses at the time of participation. All participants received academic credit for completing this phase of the study. Phase I consisted of an online survey that was posted on Survey Monkey (an online company: www.surveymonkey.com), which was linked to the UCF Psychology Department's undergraduate research participation website.

As we could not temporarily prevent minors from participating in the online questionnaire while we wait for mailed informed consent from parents, minors were excluded from participating in the study. This was primarily related to software limitations with the Experimentrak online participation sign-up tool.

Of the 920 responses collected, 143 (15%) were excluded from the analysis for meeting various exclusionary criteria. Seventeen responses were excluded for containing one or more skipped items on the primary delusion measure (Peters et al. Delusion Inventory). Participants who scored above the threshold on any of the 3 validity scales (see descriptions below) were excluded from the study due to the potential for random responding (Infrequency Scale), socially desirable responding (Abbreviated Marlowe–Crowne Social Desirability Scale - MC), and/or exaggeration of pathology (Infrequency-Psychopathology Scale from the Minnesota Multiphasic Personality Inventory-II - Fp). Thirty-six participants who scored greater than 1 on the Infrequency Scale were excluded; 16 participants were excluded for scores greater than 5 on the

Fp Scale (T greater than or equal to 85); and 33 participants who scored greater than two standard deviations above the mean on the Social Desirability Scale were excluded. The following participants were excluded because they did not meet demographic cutoffs required to participate in Phase II: 26 participants did not properly report their age; 7 participants were excluded because they reported being color-blind; 5 were excluded who reported speaking English as a second language, and 3 participants were excluded because they did not report their gender. The number of valid responses remaining was 777.

Of the 777 responses analyzed, 68.6% were female (n = 533); 77.6% identified themselves as Caucasian; 10% were Hispanic; 7.1% were African American; 2.6% were Asian/Pacific Islander; and 2.8% identified themselves as "Other." The age of the respondents ranged from 18 to 34; the mean age was 20.21, with a standard deviation of 2.3 years.

The main measure of interest included in Phase I was the PDI-21. PDI-21 total scores were analyzed for the 777 valid responses collected. The lowest possible score on the PDI-21 is 0, while the highest score possible is 336. In our sample of college students, the scores ranged from 0-194, with a mean score of 53.0, and a standard deviation of 31.6.

An independent samples t-test revealed no significant difference between males (M = 52.11) and females (M = 53.47) on PDI-21 total score $t(775) = 0.56$ $p = .58$. However, an ANOVA revealed that PDI-21 scores did differ significantly as a function of race, $F(4,772) = 9.22$, $p < .001$. Post hoc comparisons revealed that African Americans scored significantly higher on the PDI-21 (M = 75.51) than Caucasians (M = 50.17), Hispanics (M = 56.86), and those identifying themselves as other (M = 54.62). There was a statistical trend for African Americans to score significantly higher than Asians (M = 61.15) as well. A correlation revealed that PDI-21 scores did not differ across age ($r = .03$, $p = .42$).

Procedure: Phase I

Students who chose to complete this survey were initially directed to an informed consent webpage which they 'signed' electronically before beginning the survey. The informed consent included information about the study, and stated the age requirements for participation. In addition, there was a section outlining permission to contact the student in the future for further studies.

Information collected on the online survey included items from the 21-item Peters et al. Delusions Inventory, the 22-item Abbreviated Schizotypal Personality Questionnaire (SPQ-B), and demographic information such as contact information, gender, age, and race. The analysis of online questionnaire data included three validity scales: the 27-item Fp Scale from the Minnesota Multiphasic Personality Inventory-II, the 8-item Infrequency Scale, and the 13-item Marlowe-Crowne Social Desirability Scale to help ensure that participants answer in a truthful and attentive manner (see below for a description of each scale). In total, the survey consisted of 120 potential questions. The PDI-21 items were preceded by a short instruction set (see Appendix A). Due to the construction of items on the PDI-21, yes/no items were presented, followed by a cluster of 3 conditional items that were only presented when a "yes" response was endorsed to the preceding item. For example, first a yes or no question was presented, such as "Do you ever feel as if people are reading your mind?" If the individual chose "yes," he or she was then prompted to answer three more questions, which asked him or her to provide a rating (1-5) of distress, preoccupation, and conviction regarding the stated belief. If the individual answered "no," then the rating questions did not appear. The structure of the rating items were the same for all yes/no questions on the PDI-21. After all PDI-21 questions were administered in a fixed order, the three validity scales were administered. All of the validity scales shared the

"True/False" format and were thus administered in a fixed random order, with items from the different scales intermixed. The last 22 items were from the SPQ-B, and were administered in a fixed order, as the yes/no format and instructions differed from those of the validity scales. The entire questionnaire took approximately 30-40 minutes to complete, but varied from person to person. Following the test administration, students viewed an online debriefing form, which included information about the purpose of the study as well as contact information. Phase I was approved by the Institutional Review Board (IRB) at UCF.

Measures for Phase I

The 21-Item Peters et al. Delusion s Inventory (PDI-21; Appendix A) : The PDI-21 (E. R. Peters et al., 2004) is a short version of the original PDI, which contained 40 items (E. R. Peters, Day et al., 1999). The PDI, which was originally based on The Present State Examination (Wing, Cooper, & Sartorius, 1974), was designed to measure delusional ideation in a normal population. Items were chosen specifically for the purposes of measuring attenuated psychotic symptoms and sampling a wide range of delusional beliefs (E. R. Peters, Joseph et al., 1999). 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).

According to the authors, items included in the PDI-21 were chosen based on a principal components analysis (PCA) with varimax rotation, which was carried out on the participant pool

(n = 272) who completed the original 40 item version. (E. R. Peters et al., 2004). The PDI-21 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 21 points. Additionally, each dimension measured on the 5-point Likert scale can be scored, obtaining a range from 0 to 105 points. The grand total PDI-21 score can be obtained by adding up the three dimension scores and the yes/no score, for a range from 0 to 336 points.

Consistent with the 40-item PDI, scores on the PDI-21 were normally distributed in a healthy population sample (N = 444). No differences were found between males and females on yes/no scores, any of the dimensions, or on the total PDI-21 score. Significant inverse relationships with age were found on yes/no scores, all three dimension scores, and the total score. The PDI-21 was found to have adequate internal consistency (.82), and good test-retest reliability (6 months to one year later) ranging from .78 to .81 depending on the subscale. The measure was also found to have good convergent validity, as the authors reported a highly significant correlation (r = .61) between the PDI-21 and another measure of delusions, the Delusions-Symptoms-State-Inventory (Foulds & Bedford, 1975). The Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) (Mason, Claridge, & Jackson, 1995), a measure of schizotypal traits, as well as the EPQ scale, a measure of extroversion (Eysenck & Eysenck, 1975) were used to establish discriminant validity. The O-LIFE is divided into four factors and one subscale: unusual experiences (UnEx), cognitive disorganization (CogDis), introvertive anhedonia (IntAn), impulsive nonconformity (ImpNon), and the Schizotypal Personality Scale (STA), three of which correlated positively with PDI-21 yes/no scores at a 0.01 significance level, (UnEx factor, r = .65; ImpNon factor, r = .37, STA score, r = .51), and two of which did not (IntAn, r = -.31; CogDis, r = .21). The correlation between the PDI-21 yes/no score and the

EPQ score was not significant (r = .35). Criterion validity was established by comparing the scores of the healthy sample to those of a deluded psychiatric group. All scales and ratings were found to be significantly higher (p < .001) in the deluded group, as expected, although there was overlap on scores between the groups (E. R. Peters et al., 2004).

Abbreviated Schizotypal Personality Questionnaire (SPQ-B). The SPQ-B is a self-report survey designed to assess the presence of traits found in DSM-IV schizotypal personality disorder in community samples (Raine & Benishay, 1995). This measure consists of 22 items rated on a yes/no scale. The SPQ-B consists of three factors (Cognitive-Perceptual Deficits, Interpersonal Deficits, and Disorganized) that were based on questions selected from the same three factors on the longer 74-item Schizotypal Personality Questionnaire (Raine, 1991). Questions that appeared the most reliable and valid from the full SPQ were chosen during the development of the SPQ-B. The Cognitive-Perceptual Deficits factor captures constructs of ideas of reference, odd beliefs, magical thinking, unusual perceptual experiences, and paranoid ideation; the Interpersonal Deficits factors captures constructs of social anxiety, lack of close friends, and constricted affect; and the Disorganized factor captures constructs of odd behavior and speech.

The three factors and total score from the SPQ-B have internal reliabilities ranging from .72 to .80, correlations with the full 74-item SPQ ranging from .89 to .94, and test-retest reliabilities across a 2 month interval between .86 to .95 (Axelrod, Grilo, Sanislow, & McGlashan, 2001; Raine & Benishay, 1995). Correlations between SPQ-B total score/factors and clinical interview measures of schizotypal personality disorder are good (ranging from .63 to .73), except for the Disorganized factor, which is poor (r =.36). Thus, with the exception of criterion validity for the Disorganized factor, the SPQ-B has solid psychometric properties.

Previous research on responses from 220 male and female undergraduates, revealed a mean SPQ-B total score of 9.6 with a standard deviation of 5.3 (Raine & Benishay, 1995). The authors of the scale suggest that most individuals with schizotypal personality disorder will score in the top 10% of a given sample on the SPQ-B total score.

Infrequency-Psychopathology Scale from the Minnesota Multiphasic Personality Inventory-II (Fp; Appendix B). The Fp scale is comprised of items that are rarely endorsed in the keyed direction by psychiatric patients or nonpsychiatric controls (Butcher et al., 2001). This scale is sensitive to individuals who are exaggerating psychopathology because many of the items represent particularly rare symptoms of psychopathology (e.g. "Everything tastes the same").

Scale modeled after the Infrequency Scale of Personality Research Form (Appendix C): An 8-item scale modeled after the Infrequency Scale of Personality Research Form was also used as a validity scale. This scale provided a measure of whether participants responded in a random fashion when filling out items on the survey by asking participants to answer "true" or "false" to a number of extremely improbable questions, such as "I visited Easter Island last year" (Calkins, Curtis, Grove, & Iacono, 2004; Jackson, 1984).

Abbreviated Marlowe–Crowne Social Desirability Scale (MC; Appendix D). The third validity scale included in this portion of the study was the Abbreviated Marlowe–Crowne Social Desirability Scale (Crowne & Marlowe, 1960), a 13-item self-report scale based on the 33-item version that examines whether participants answer according to what they perceive to be socially appropriate responses. The 13-item form was found to have acceptable internal consistency reliability (r = .76), comparable to the standard form and other short forms (Reynolds, 1982). The 13-item version of the Marlowe-Crowne Social Desirability Scale was also found to have

strong reliability with the Marlowe-Crowe Standard form (*r* =.93). In order to establish convergent validity, the 13-item version of the scale was correlated with the Edward's Social Desirability Scale (SDS). Although the correlation between the two measures was low (r = .41), the authors suggested that this was due to restricted range of scores on the Edward's scale (Reynolds, 1982).

Phase II

Participants for Phase II

Individuals were invited to participate in Phase II based on their score on the PDI-21 obtained during Phase I. In order to obtain a wide distribution of delusional-proneness, participants were recruited representing a broad range of PDI-21 scores from the initial sample of 777 participants that met the validity and exclusionary criteria. Other demographic characteristics that were taken into consideration during the recruitment process were gender, age, and ethnicity. Specifically, an attempt was made to recruit participants whose demographic variables approximated those of the Phase I demographic breakdown. The amount of time between completion of Phase I measures and participation in Phase II ranged from one to 11 weeks (mean = 3 weeks, SD = 2.5 weeks).

As it appears that no published study has investigated the relationship between the PDI-21 and Stroop performance in college students, two power analyses were conducted on two relatively similar studies, and the effect sizes from both were averaged in order to obtain a sample size estimate. One of the two effect sizes was obtained from a previous study comparing cognitive functioning in deluded psychiatric patients to that of non-clinical controls (E. R. Peters & Garety, 2006). Briefly, this was a study which administered both the PDI-21 and the Stroop

task to the deluded group and the control group. However the authors investigated the relationship between groups on these measures in a dichotomous manner, whereas the current study will be investigating the relationship between both measures on a continuum. Therefore, for the purposes of conducting a power analysis for the current study, we first obtained the effect size for performance on the incongruent condition of the Stroop task (RT) of the deluded group (when they were no longer floridly psychotic) compared to performance of control participants (who performed significantly better), which revealed a large effect size (Cohen's $d = 2.23$) . We then converted the effect size into an r value of 0.74 using the following simplified formula provided by Hunter and Schmidt (2004), used to estimate r from d when group sizes are approximately equal: $d / \sqrt{(d^2 + 4)}$. Although the Peters and Garety (2006) study utilized the same measures as the current study, certain differences, such as the use of an inpatient deluded sample, as well as the use of dichotomized groups, preclude direct comparison to the current study.

The second study included in the power analysis was an investigation of delusion-proneness in college students (using the PDI-21) and performance on a computerized cognitive task measuring reaction time of processing different facial expressions (Green et al., 2003). This study also looked at two dichotomized groups and reported that the group that scored high on the PDI-21 displayed a significant delay (increased response latency) in processing angry facial expressions in comparison with the low scoring group. Although this study used the PDI-21 and more closely approximated our proposed sample (college students), the cognitive task employed cannot be equated with a Stroop task. Following the same procedure described above, this study found a medium effect size (Cohen's $d = .54$) from which an r value of 0.27 was estimated. This value was then averaged with the effect size from the study by Peters and Garety to yield an

estimated effect size of $r = 0.51$. Based on Cohen's (1992) recommendations for power analysis, it is estimated that a minimum sample size of 35 participants will be needed for the current study. This estimate is based on an alpha value of .05 (two-tailed), a medium effect size of $r = 0.51$, and power of 0.90.

A total of 41 individuals participated in Phase II of the study. Participants were screened for visual acuity, and all participants obtained a 20/30 or better on a standard Snellen vision chart. All Phase II participants self-reported that they spoke English as a first language and denied any color-blindness.

Phase II participants were screened for the presence of psychotic symptoms, and none of them met diagnostic criteria for a current psychotic disorder based on a structured clinical interview (Psychotic Disorder portion of the Structured Clinical Interview for DSM-IV Axis I Disorders; SCID-I). This was done to help ensure that individuals endorsing psychotic symptoms, such as hallucinations, as well as negative symptoms, were not included, as this would introduce a number of confounds into the study. Participants were screened for the presence of schizotypal personality disorder (SPD) and paranoid personality disorder (PPD). None of the participants met diagnostic criteria for either disorder, based on a structured clinical interview (Structured Clinical Interview for DSM-IV Axis II Disorders SCID-II; see below).

After excluding 5 participants for unreliable Stroop data (see Phase II Procedures below) and 1 additional participant who was a statistical outlier in the primary analyses (see Results section), the total number of participants included in data analysis was 35, 25 of which were female (71.4%). The majority of participants identified themselves as Caucasian (77.1%); 2.9% were Hispanic; 2.9% were African American; 11.4% were Asian/Pacific Islander; and 5.7%

identified themselves as "Other." The age of the participants ranged from 18 to 23; the mean age was 20.05, with a standard deviation of 1.27 years.

The mean PDI-21 total score among the 35 participants was 76.03, with a standard deviation of 36.89. Scores ranged from 17 to 148. An independent samples *t*-test revealed no significant difference between males ($M = 72.5$, $SD = 45.4$) and females ($M = 77.4$, $SD = 33.9$) on PDI-21 total score $t(33) = 0.35$, $p = .73$.

Measures for Phase II

Visual Acuity Chart: Visual acuity was measured using a standard Snellen wall chart which provided a basic measure of visual acuity (the ability of the eye to focus). The chart has a series of letters, with the largest at the top. As the individual reads down the chart, the letters gradually become smaller. The chart was placed on a wall at eye level, 20 feet from the individual. Each participant was asked to read one row at a time from the top of the chart to the bottom. Each row of the chart assesses a distinct level of visual acuity. The fractions (i.e.; 20/20, 20/30, etc.) are levels of visual acuity and reflect the ability to identify a letter of a certain size at a specified distance.

Structured Clinical Interview for DSM IV Axis I Disorders (SCID-I). The SCID-I is a semi-structured clinical interview used to assess whether an individual meets diagnostic criteria for DSM-IV-TR Axis I Disorders (M. B. First, Gibbon, R.L., & William, 1997). The interview contains directions for scoring answers in order to derive DSM-IV-TR diagnostic labels. The SCID-I has been shown to be both a reliable measure for determining if an individual meets criteria for an Axis I DSM-IV-TR diagnosis with excellent interrater reliability (kappa = 0.85, range = 0.71 to 0.97) and diagnostic accuracy (82%), when compared with the "gold standard" of

consensus diagnosis (Ventura, Liberman, Green, Shaner, & Mintz, 1998). For the purpose of screening participants for symptoms of psychosis, only a small portion of the SCID-I was administered. This included parts of the "Overview" section of the SCID-I, which consists of questions concerning basic demographic information, as well as questions about past treatment for both physical and mental health, as well as current medications. Part B of the SCID-I, entitled "Psychotic and Associated Symptoms" was also administered in its entirety, and contains questions about delusions, hallucinations, and other symptoms of psychosis. Administration time ranged between 5-10 minutes.

Schizotypal Personality Disorder and Paranoid Personality Disorder Sections of the Structured Clinical Interview for DSM IV Axis II Personality Disorders (SCID-II). The 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, 1997). The current study administered only the sections for schizotypal personality disorder (SPD) and paranoid personality disorder (PPD), because both of those disorders have been established as genetically and phenomonologically related to schizophrenia. Items on the SCID-II are scored on a 3-point scale (absent/false = 1, subthreshold = 2, threshold/true = 3). A categorical diagnosis of SPD is obtained when the number of "3's" reach the diagnostic threshold according to criteria in the 4th ed. of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2000). In addition, a dimensional index of SPD was calculated by summing the raw scores (1-3) from each item. The administration time for these two portions of the SCID-II ranged from 5-10 minutes. .

The Stroop Task: A computerized Stroop task was administered. Participants were seated 18 inches away from a 22-inch NEC Multisync FP 2141^{SB} monitor 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 their responses.

Several variations of the Stroop task exist. The current study employed a three condition (congruent, incongruent, and neutral) Stroop task with four color choices- red, green, blue, and yellow. During the neutral condition, a row of four "X's" appears in one of the four colors. The neutral condition serves as baseline measure of reaction time of simply responding to color, since there is no reading component and thus no interference during neutral trials. During the congruent condition, a color word appears in matching, or congruent font color (i.e the word RED appears in red font). During the incongruent task, the color word and the actual color of the font is different (i.e. the word GREEN written in red font). The incongruent trials require the participant to suppress the habitual reading response, thus creating interference.

A total of 120 trials were administered, equally divided into 40 trials of each of the three conditions. All 120 trials were presented in a fixed semirandom order, with the restriction that following an incongruent trial, the answer (font color) of the next trial was not that of the color-word that the participant just ignored during the preceding incongruent trial. This was done in order to avoid confounds due to the priming effect. 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 their response, which was detected by the microphone, and triggered 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 also manually coded for accuracy by the experimenter during the 2000 ms intertrial interval. The experimenter coded each response using a response box connected to the computer, and also recorded any microphone errors or instances in which a microphone response was triggered incorrectly (i.e. the participant coughs, etc.). A 15 trial practice session (5 trials of each of the 3 conditions) 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 from the administrator concerning their performance. The total amount of time needed to complete the task, including practice trials, ranged from 4 to 6 minutes.

The Stroop task is one of the most widely used neuropsychological tasks. In a study investigating the test-retest reliability of a computerized single-trial Stroop task over a one week period, the authors reported that RTs for congruent and incongruent conditions were highly reliable ($r = 0.46$) at $p < .05$ (G. P. Strauss, Allen, Jorgensen, & Cramer, 2005).

Procedure: Phase II

Research was conducted in the Clinical Cognitive Neuroscience Laboratory on the UCF campus. Each participant began by completing written informed consent. Participants were then given a brief description of the protocol and the voluntary nature their participation.

Additionally, they were informed that they could discontinue at any time without penalty. Participants were then given the opportunity to ask any additional questions they may have had before signing informed consent.

Participants were then tested for visual acuity, followed by the brief clinical interview consisting of the selected portions of the SCID-I and SCID-II. Next, participants completed the computerized Stroop task. After completing the Stroop task, participants were debriefed. The total session length ranged from 25-35 minutes.

Data collected during the Stroop task was later filtered in order to exclude invalid trials from the data analysis. Initial examination of raw data showed a small number of individual trials for which the reaction time was 0, indicating equipment failure (the microphone did not trigger a response), as well as a small number of trials with abnormally long reaction times recorded. This was likely due to instances when respondents had to repeat responses that were not detected by the microphone. In order to exclude these responses, a filter was applied that deleted individual trials for which the reaction time was 0 ms, or greater than 2000 ms. Reaction time and accuracy scores were therefore calculated without these trials, as the inclusion of these trials may have added noise to the data. Responses were then checked on a case by case basis to screen for instances when more that 15% of responses were excluded following the procedures just described. Each "block" of trials (incongruent, congruent, and neutral) was screened, and if any block found to contain 6 or more invalid trials (34 or less valid out of a possible 40), all of the participant's data were excluded from the final data analysis. This resulted in the exclusion of 5 participants, bringing the total number of participants with valid Stroop performance to 36.

RESULTS

Stroop indices that were investigated included the 'interference effect,' which was calculated for the primary analysis by subtracting RT from correct congruent trials from RT in correct incongruent trials. For the secondary set of analysis, an interference score was calculated by subtracting reaction time (RT) of the correct trials from the neutral condition from the RT of the correct trials from the incongruent condition. Both of these contrast measures were explored separately, as the contrast score between neutral and incongruent conditions controls for basic processing speed, while the contrast score between congruent and incongruent trials controls for both basic processing and reading speed. Additionally, accuracy contrast scores were calculated by using the same procedure to create differences scores using number of errors made between conditions instead of RT.

In order to check the data for outliers, both Cook's Leverage values and the Studentized Residuals were examined on each of the four Stroop contrast score predictors independently on the PDI-21 score. Following the generally accepted rule of thumb for each respective procedure, cases with either a Cook's D value greater than 1.0, or a Studentized Residual value greater than 2.0 were flagged for exclusion. Examination of the Cook's Leverage values revealed that no cases exceeded the cutoff on any of the predictor variables. However, examination of the Studentized Residuals revealed one case with values above the cutoff on three of the four predictor variables. Therefore, this case was deemed to be a statistical outlier and was excluded from all further analysis, bringing the final number of valid cases to 35.

In order to assess whether the dependent variable and four predictor variables were normally distributed, a Shapiro-Wilk's statistical test of normality was conducted. The analysis revealed that PDI-21 scores, which served as the dependent variable in all main analyses, were normally distributed, as was the RT contrast score between incongruent and congruent trials.

For our primary analysis, a stepwise linear regression was performed, with the PDI-21 score as the dependent measure and the two performance indices (accuracy and reaction time) from the Stroop incongruent minus congruent contrast as predictors. Entry criteria was set at p =.05; exit criteria was set at p =.10. Only one of the predictor variables entered the model- the reaction time (RT) contrast score, $F(1, 33) = 6.49$, $p = .02$, $R^2 = .16$; medium effect size (see Figure 1). This finding was consistent with our hypothesis, in the direction expected (as delusion-proneness increased, RT contrast score increased). The second predictor, accuracy contrast score, did not enter the model; however, a subsequent correlation revealed that there was a statistical trend for this relationship, $r = .31$, $p = .07$. This relationship was in the predicted direction- as the PDI-21 scores increased, the accuracy contrast scores increased. The Variance Inflation Factor was well below the suggested cutoff of 3 for both of these predictors, suggesting no significant problem with multicollinearity

A second stepwise linear regression was conducted using the same procedure with the alternate Stroop interference contrast scores (incongruent minus neutral). This analysis revealed that accuracy contrast, rather than RT contrast, predicted PDI-21 score in this alternate condition, $F(1, 33) = 4.12$, $p = .05$, $R^2 = .11$; medium effect size (see Figure 2). Interestingly, RT contrast did not enter the model, and subsequent examination of the correlations revealed that this relationship did not approach statistical significance ($r = .26$, $p = .13$). The Variance Inflation

Factor was well below the suggested cutoff of 3 for both of these predictors, suggesting no significant problem with multicollinearity.

In addition, non-linear trend analyses were conducted to test the hypothesis that possible relationships from the primary analyses would be best explained by an exponential curve. This was not the case in the primary analysis of incongruent/congruent RT contrast scores. However, in the case of the incongruent/neutral accuracy contrast scores, an exponential curve (R^2 = .12, $F(1, 33) = 4.39$, $p = .04$) provided a slightly better fit than the linear model (R^2 = .11, $F(1, 33) = 4.12$, $p = .05$). Other types of nonlinear trends (e.g., cubic, quadratic) were examined for each of these contrast scores, and none produced a better fit.

Exploratory analyses were conducted in order to examine any possible interaction of gender on both the primary and secondary findings. In terms of reaction time contrast scores, in both sets of analyses, gender did not show a statistically significant interaction in either case (incongruent/congruent contrast; incongruent/neutral contrast), as revealed by an ANOVA. In the case of accuracy contrast scores, however, gender was found to have a statistically significant interaction in both cases. An ANOVA revealed that the interaction between gender and accuracy interference scores in the incongruent/congruent contrast analysis was statistically significant, $F(1, 31) = 9.43$, $p = .005$. Further post hoc tests revealed that only the males in the sample showed a statistically significant relationship between this Stroop index and PDI-21 score (r = -.88, $p = .001$), while females did not display this effect (r = -.01, $p = .98$), suggesting that the males were driving the statistical trend for accuracy contrast described in the primary analysis (incongruent/congruent). Additionally, for the statistically significant finding on accuracy in the incongruent/neutral condition, the interaction between gender and interference scores was again significant, $F(1, 31) = 4.54$, $p = .04$. Similar to the findings in the congruent/incongruent

accuracy contrast, only males showed this effect (r = -.73, p = .02), while females did not (r = -.14, p = .49).

Further exploratory analyses were conducted in order to investigate the relationship between the four Stroop contrast scores used in the main and secondary analysis, and our secondary measures of schizotypy and paranoid features. A series of correlations examined the relationship between each of the four Stroop performance indices with the SPQ-B score, as well as with the dimensional index scores from the SCID-II Schizotypal and Paranoid Personality measures (see Table 1). The analyses revealed that there was a statistically significant correlation between the incongruent/congruent accuracy contrast score and Paranoid Personality dimension scores (r = .42, p = .01). None of the remaining symptom measures approached a statistically significant relationship with the Stroop performance measures. Due to our finding that gender showed a significant interaction with this particular Stroop measure in our previous analysis of the accuracy indices, the influence on gender on this relationship was explored. Subsequent inspection of the scatterplots indicated that again, this finding was specific to males, and may have been largely driven by a particular male with the highest Paranoid Personality score. Other correlations were performed to investigate whether PDI-21 scores were significantly related to any of the measures of schizotypy and paranoid features (see Table 1). There was a significant correlation between PDI-21 scores and the: SPQ-B total score (r = .60, p < .001); Schizotypal Personality Disorder dimension score (r = .51, p = .002); and Paranoid Personality Disorder dimension score (r = .53, p = .001).

DISCUSSION

The aim of the current study was to examine the relationship between Stroop task performance and level of delusion-proneness. The Stroop task was chosen as it has been previously demonstrated to be sensitive to individual differences in anterior cingulate cortex (ACC) functioning, and reduced ACC functioning (using neuroimaging) has been related to clinical delusions in several psychiatric disorders. While Stroop task performance is also sensitive to individual differences in other brain regions (e.g., dorsolateral prefrontal cortex), hypothesized individual differences in ACC functioning should theoretically be reflected in behavioral Stroop performance – primarily in measures of efficiency, such as reaction time. However, individual differences in Stroop behavioral performance do not necessarily reflect individual differences in ACC functioning. Specific neuroanatomical relationships are best examined with neuroimaging techniques.

It was hypothesized that there would be a relationship between delusion-proneness as measured by the PDI-21 and a reaction time contrast score (incongruent minus congruent condition), and that this relationship would be best explained by an exponential curve. Consistent with our hypothesis, the primary finding in the main analysis was that, compared to accuracy, reaction time (RT) showed a stronger relationship with delusion-proneness; however, this relationship was best explained by a linear, rather than exponential, regression line. As participants' PDI-21 score increased, the RT contrast score increased, indicating a delayed response to incongruent trials relative to congruent trials. As both of these conditions measure

basic processing speed and reading speed, the primary difference in task demands is that incongruent trials have the added component of requiring inhibition of habitual responding.

It was hypothesized that, in the main analysis, accuracy interference scores would also predict PDI-21 score, albeit to a lesser extent than RT. The results of the stepwise regression suggest that although this performance index did not enter the model, there was a statistical trend for statistical significance in expected direction. That is, as PDI-21 score increased, participants made more errors in the incongruent relative to the congruent condition. Taken together with the RT findings, this pattern of results suggests that *efficiency* of performance was more strongly related to delusion-proneness, rather than the more gross measure of accuracy. Considering that our sample consisted of college students, and that a ceiling effect in accuracy scores was found (mean accuracy for incongruent condition = 97.9%, SD = 2.6, range = 92 to 100), the findings from the main analysis are not surprising. Notably, 54% of the sample made no errors on the incongruent condition, which is the most difficult condition that was presented. In contrast, the reaction time from the incongruent condition showed considerable variability (mean = 728.4 ms, SD = 113.9, range = 571.5 to 1080.0).

The findings from the secondary analysis, which calculated Stroop interference scores by contrasting incongruent and neutral trials, suggest that there is a differential relationship between delusion-proneness and this index of Stroop performance, as compared to the interference index used in the main analysis. Results of these analyses show that accuracy contrast was a statistically significant predictor of PDI-21 scores; however, RT contrast scores did not predict PDI-21 scores as found with the alternate contrast score. Considering the statistical trend for accuracy contrast scores to relate to PDI-21 scores using the incongruent/congruent contrast, the finding that accuracy interference scores entered the model in this analysis was not surprising.

What was not expected was that the RT interference finding, which was robust in the main analysis, did not approach statistical significance in the secondary analysis. One possible explanation for this discrepancy is that neutral trials of the Stroop task (naming the font color of "X's") do not control for the reading component common to both the congruent and incongruent trials. Therefore, the differential results suggest that the PDI-21 was not strongly related to the reading component of the incongruent condition. Thus, when the cognitive process of reading is lumped together with the inhibition process within the incongruent-neutral contrast, noise is added to the relationship between the PDI-21 and the incongruent condition inhibition effects.

This study appears to be the first to investigate the relationship between delusional-proneness in a nonpsychiatric population and a behavioral measure of ACC function (Stroop task). In a previous study, which investigated Stroop performance in deluded psychiatric patients, non-deluded psychiatric patients, and nonpsychiatric adults, Peters and Garety (2006) reported that the nonpsychiatric control group had significantly faster RT's than both the psychiatric groups (who did not differ from each other). The same pattern was found for overall error rates. However, at follow-up, the deluded psychiatric patients, who were now in remission, showed significantly slower RT's than both the non-deluded psychiatric group and the nonpsychiatric control group. While the current study did not include a clinically deluded group, our main finding that delusion-proneness predicted RT contrast in a continuous fashion is consistent with the RT differences reported in Peters and Garety's dichotomized groups. In addition, the current study investigated delusion-proneness as a continuum, rather than creating categorically defined groups, which has been suggested by some to be more consistent with an overall continuum hypothesis of psychosis (Warman, Lysaker, Martin, Davis, & Haudenschield, 2006). This model, which states that delusions are not all-or-nothing false beliefs, but rather can

be measured as points on a continuum of normal to pathological functioning, is also consistent with a cognitive model of psychosis. This model suggests that cognitive functioning, which was measured in our study using the Stroop task, may be related to delusion severity in a continuous manner, an idea that was supported by our main finding that delusion-proneness was associated with longer RT contrast scores in the incongruent (more cognitively demanding) condition relative to the congruent condition.

As the current study was correlational, there is no way to determine any kind of causality in terms of whether delusion-proneness is due to cognitive dysfunction related to ACC functioning. However, based on previous work in this area, it is possible that the observed relationship between Stroop performance and delusion proneness is due to overlapping neural pathways (potentially involving the ACC) common to both conflict monitoring and delusion formation. It is also possible that a reduced capacity for monitoring conflict/errors related to discrepancies between internally-generated thoughts and external reality might contribute to the formation and/or maintenance of delusions *and* be manifested behaviorally when performing tasks high in conflict response monitoring.

Identifying the cognitive correlates of delusion-proneness could have important implications for treating individuals who are experiencing clinical delusions. Some researchers have suggested that when treating individuals presenting with delusions (regardless of the disorder), specific types of interventions should be considered (Kuipers et al., 2006). According to the cognitive model of psychosis, psychotic experiences exist as a continuum with normal experiences. One factor that may contribute to a symptom becoming pathological is cognitive dysfunction, particularly reasoning biases, which appear to play a role in symptom formation and maintenance. The authors suggest that the effectiveness of cognitive-behavioral therapy (CBT) in

psychotic populations may be enhanced by dealing with high belief convictions by helping to compensate for reasoning biases. Specifically, the following suggestions were made by the authors: 1) In order to help individuals with strong delusional conviction, which is related to belief inflexibility and an inability to generate alternative hypotheses, work slowly on the acknowledgement that other explanations may be credible; 2) Test out new explanations (which you may need to help the client generate) collaboratively in order to test credibility; 3) Develop strategies for clients to gather more information before jumping to a decision ("thinking the second thought"); 4) Disconfirmation as a way of testing competing theories is a less commonly used strategy in delusional individuals, so encourage clients to employ this technique by looking for instances which *do not* fit with predictions; 5) Work collaboratively with clients to "see what happens" when using new these techniques (especially those that may be suspicious), and gradually encourage them to drop their safety behaviors and avoidance (Kuipers et al., 2006).

One limitation to the current study was the use of college students in our sample. Although this population presented a number of advantages in terms of avoiding confounds inherent to studying a psychiatric population (e.g. long-term antipsychotic use, the presence of other psychiatric symptoms), there were drawbacks that may affect the generalizability of the findings. One drawback was the restricted age range in our sample, as all participants were between the ages of 18 and 23. A second limitation to using a college population is restricted range in both cognitive and psychiatric functioning (e.g., delusional propensity) that is assumed in this population, as compared to a community-based sample.

Another limitation in the current study was unequal gender distribution of participants favoring females. Although there were no gender differences on the dependent measure (PDI-21), post-hoc analysis revealed that gender had a significant interaction on some of the secondary

findings. Although gender did not affect our main findings of interest (RT), the less robust accuracy findings were driven by gender (with males showing the stronger relationship). It also appeared, based on visual inspection of the scatterplots, that one male in particular may have been driving the accuracy findings. As the majority of this sample was female, the uneven gender distribution could in part explain why our combined (female and male) sample resulted in strong RT findings, while the accuracy findings were relatively weaker. In the literature, the majority of studies on Stroop performance suggest that there are no gender differences (MacLeod, 1991). However, at least one study reported gender differences in reaction time (men were slower), but not error rates, under standard task conditions (Mekarski, Cutmore, & Suboski, 1996). In a study investigating Stroop performance under mild anxiety, gender differences were reported. Women were more accurate than men, and it was reported that men displayed a speed/accuracy tradeoff whereas women did not (von Kluge, 1992). Consistent with the majority of Stroop research, the current study did not find any suggestion of gender differences on Stroop performance (incongruent/congruent contrast) for either accuracy, $t(33) = 0.55$, $p = .59$, or reaction time, $t(33) = 0.92$, $p = .37$.

Despite these limitations, our findings, particularly from our main analysis, have led us to speculate that in a community population we might find even larger differences than in our sample of college students. A community sample with a more diverse range among variables such as age and intellectual functioning could potentially replicate and strengthen the findings reported here. Additionally, as our sample did not represent extreme ends on a continuum of delusional-proneness, particularly on the high end, extending the range of delusion-proneness could potentially determine whether the linear relationship reported in the current study holds up in individuals reporting delusion-proneness comparable to that found in psychotic populations.

Based on the findings of the current study, there appears to be a clear need for neuroimaging research in order to clarify whether ACC activation differences are indeed related to levels of delusion-proneness. Additionally, the findings from the current behavioral study support the need for a more expensive and time-consuming neuroimaging study to clearly establish the magnitude and specificity of the contribution of the ACC, relative to other brain regions implicated in delusions (e.g., dorsolateral prefrontal cortex). It is possible that the ACC and/or the attentional networks involving the ACC may contribute to the formation and maintenance of delusional thought through the cognitive processes thought to be mediated by these regions of the brain. A better understanding of both the neural and cognitive correlates could pave the way for more targeted treatment for those experiencing clinical delusions, as a modified version of CBT is currently being developed for the treatment of delusions, and it is possible that future pharmacological treatments could be designed to target the brain regions that are implicated in the formation and maintenance of delusional thought.

APPENDIX A: PETER'S ET AL. DELUSION INVENTORY

Appendix

P.D.I.-21

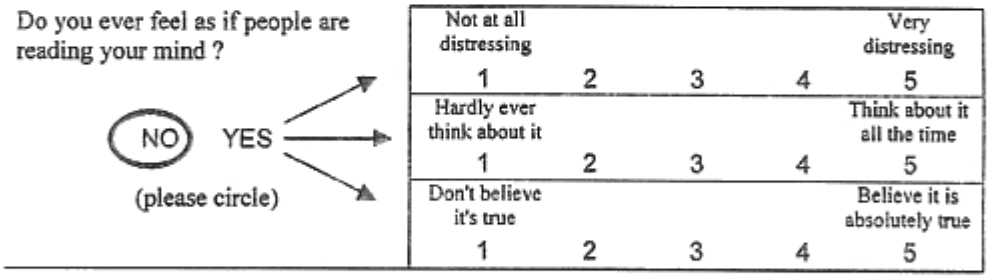
This questionnaire is designed to measure beliefs and vivid mental experiences. We believe that they are much more common than has previously been supposed, and that most people have had some such experiences during their lives. Please answer the following questions as honestly as you can. There are no right or wrong answers, and there are no trick questions.

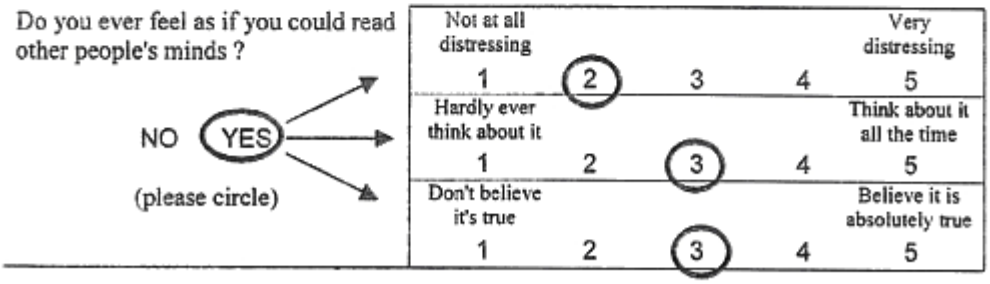
Please note that we are NOT interested in experiences people may have had when under the influence of drugs.

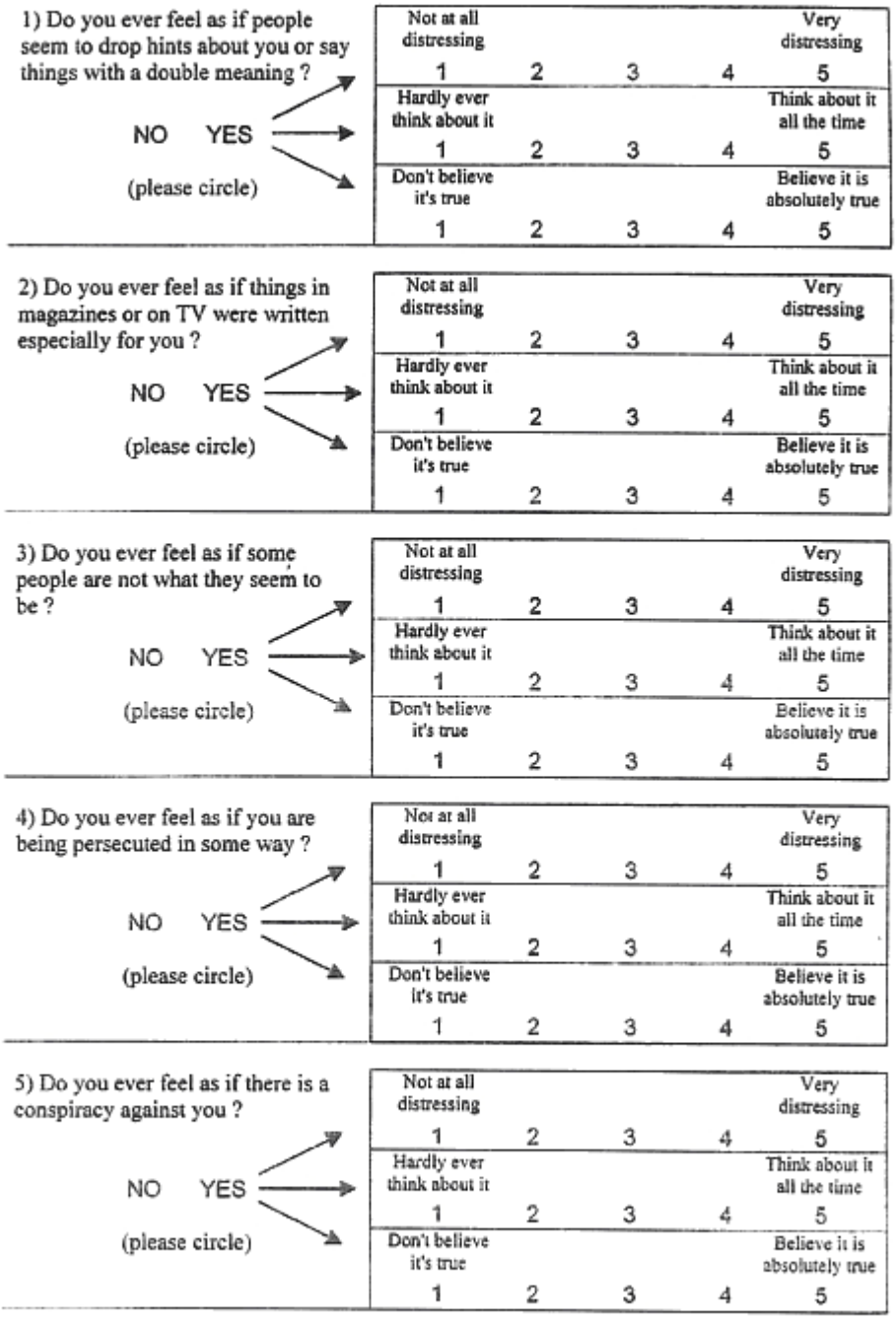
IT IS IMPORTANT THAT YOU ANSWER *ALL* QUESTIONS.

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: and
(c) how true you believe them to be.
On the right hand side of the page we would like you to 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.
If you answer NO please move on to the next question.

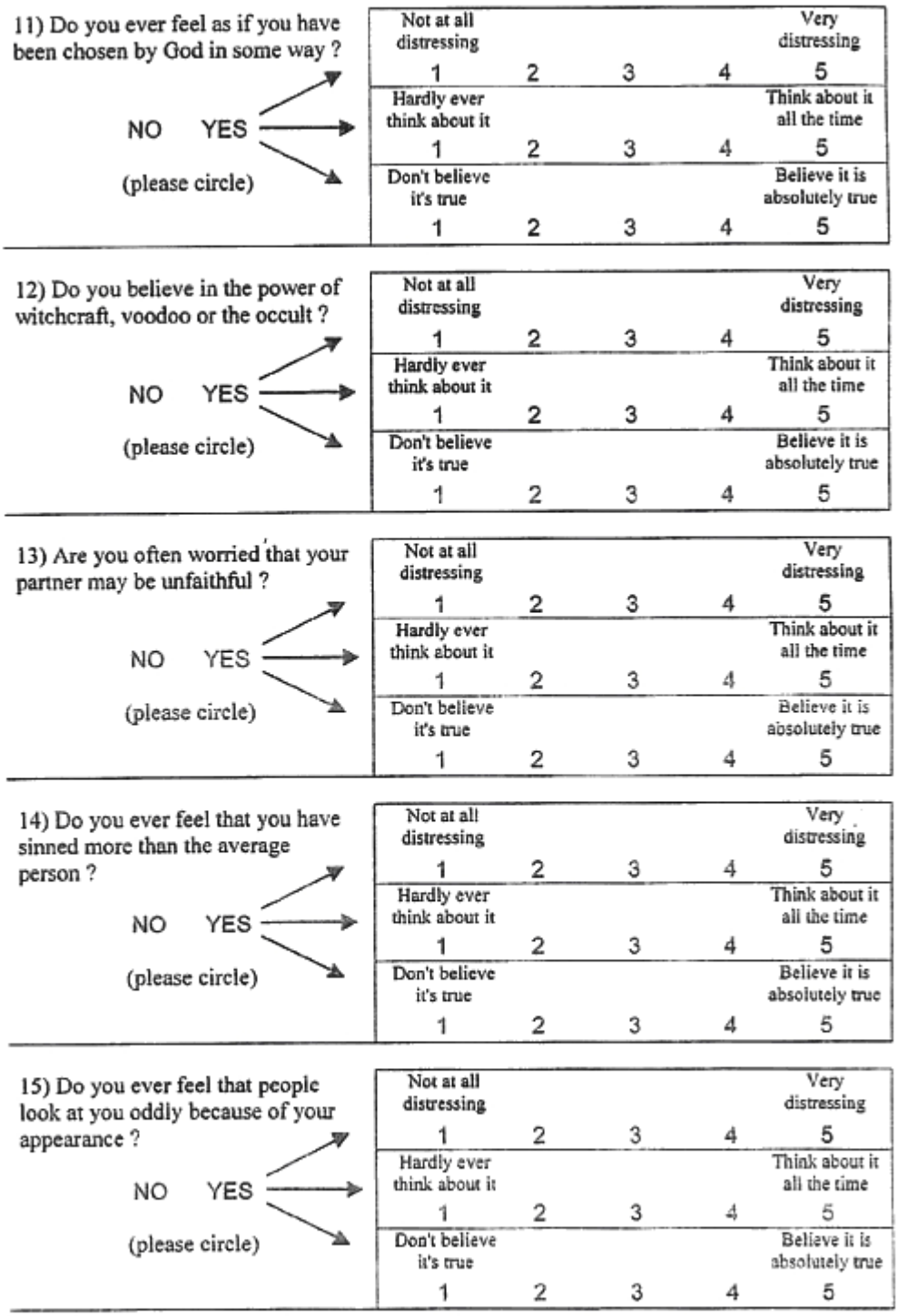
Example






1) Do you ever feel as if people seem to drop hints about you or say things with a double meaning ?
NO YES
(please circle)
Not at all distressing
Very distressing
1 2 3 4 5
Hardly ever think about it
Think about it all the time
1 2 3 4 5
Don't believe it's true
Believe it is absolutely true
1 2 3 4 5
2) Do you ever feel as if things in magazines or on TV were written especially for you ?
NO YES
(please circle)
Not at all distressing
Very distressing
1 2 3 4 5
Hardly ever think about it
Think about it all the time
1 2 3 4 5
Don't believe it's true
Believe it is absolutely true
1 2 3 4 5
3) Do you ever feel as if some people are not what they seem to be ?
NO YES
(please circle)
Not at all distressing
Very distressing
1 2 3 4 5
Hardly ever think about it
Think about it all the time
1 2 3 4 5
Don't believe it's true
Believe it is absolutely true
1 2 3 4 5
4) Do you ever feel as if you are being persecuted in some way ?
NO YES
(please circle)
Not at all distressing
Very distressing
1 2 3 4 5
Hardly ever think about it
Think about it all the time
1 2 3 4 5
Don't believe it's true
Believe it is absolutely true
1 2 3 4 5
5) Do you ever feel as if there is a conspiracy against you ?
NO YES
(please circle)
Not at all distressing
Very distressing
1 2 3 4 5
Hardly ever think about it
Think about it all the time
1 2 3 4 5
Don't believe it's true
Believe it is absolutely true
1 2 3 4 5

6) Do you ever feel as if you are, or destined to be someone very important ? NO YES (please circle)	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 that you are a very special or unusual person ? NO YES (please circle)	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 feel that you are especially close to God ? NO YES (please circle)	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 think people can communicate telepathically ? NO YES (please circle)	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 you ever feel as if electrical devices such as computers can influence the way you think ? NO YES (please circle)	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 you have been chosen by God in some way ?
NO YES
(please circle)
Not at all distressing
Very distressing
1 2 3 4 5
Hardly ever think about it
Think about it all the time
1 2 3 4 5
Don't believe it's true
Believe it is absolutely true
1 2 3 4 5
12) Do you believe in the power of witchcraft, voodoo or the occult ?
NO YES
(please circle)
Not at all distressing
Very distressing
1 2 3 4 5
Hardly ever think about it
Think about it all the time
1 2 3 4 5
Don't believe it's true
Believe it is absolutely true
1 2 3 4 5
13) Are you often worried that your partner may be unfaithful ?
NO YES
(please circle)
Not at all distressing
Very distressing
1 2 3 4 5
Hardly ever think about it
Think about it all the time
1 2 3 4 5
Don't believe it's true
Believe it is absolutely true
1 2 3 4 5
14) Do you ever feel that you have sinned more than the average person ?
NO YES
(please circle)
Not at all distressing
Very distressing
1 2 3 4 5
Hardly ever think about it
Think about it all the time
1 2 3 4 5
Don't believe it's true
Believe it is absolutely true
1 2 3 4 5
15) Do you ever feel that people look at you oddly because of your appearance ?
NO YES
(please circle)
Not at all distressing
Very distressing
1 2 3 4 5
Hardly ever think about it
Think about it all the time
1 2 3 4 5
Don't believe it's true
Believe it is absolutely true
1 2 3 4 5

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

NO YES (please circle)

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

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

NO YES (please circle)

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

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

NO YES (please circle)

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

19) Have your thoughts ever been so vivid that you were worried other people would hear them ?

NO YES (please circle)

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

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

NO YES (please circle)

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

21) Do you ever feel as if you are a robot or zombie without a will of your own ? NO YES (please circle)	Not at all distressing				Very distressing
	1	2	3	4	5
	Hardly ever think about it				Think about it all the time
	1	2	3	4	5
	Don't believe it's true				Believe it is absolutely true
	1	2	3	4	5

APPENDIX B: INFREQUENCY-PSYCHOPATHOLOGY SCALE (FP SCALE)

Infrequency-Psychopathology Scale (Fp Scale)

Instructions: If the statement is **true** or **mostly true**, as applied to you, click true (T). If a statement is **false** or **not usually true**, as applied to you, click false (F).

True	False	1.	It would be better if almost all laws were thrown away.
True	False	2.	Sometimes I am so strongly attracted by the personal articles of others such as shoes, gloves, etc., that I want to handle or steal them, though I have no use for them.
True	False	3.	Someone has been trying to poison me.
True	False	4.	In walking I am very careful to step over sidewalk cracks.
True	False	5.	Someone has been trying to rob me.
True	False	6.	There are persons who are trying to grab everything they can get in this world.
True	False	7.	Everything tastes the same.
True	False	8.	I never worry about my looks
True	False	9.	I have been told that I walk during sleep.
True	False	10.	I have never been in love with anyone.
True	False	11.	My neck spots with red often.
True	False	12.	I am afraid of using a knife or anything very sharp or pointed.
True	False	13.	Sometimes I enjoy hurting persons I love.
True	False	14.	Someone has control over my mind.
True	False	15.	I have often wished I were a member of the opposite sex.
True	False	16.	I can express my true feelings only when I drink.
True	False	17.	I hate my whole family.
True	False	18.	I can't go into a dark room alone even in my own home.
True	False	19.	I do not read every editorial in the newspaper everyday.
True	False	20.	Once in a while I put off until tomorrow what I ought to do today.
True	False	21.	I love my father, or (if your father is dead) I loved my father.
True	False	22.	Sometimes when I am not feeling well I am irritable.
True	False	23.	I get angry sometimes.
True	False	24.	I believe in law enforcement.
True	False	25.	My mother is a good woman, or (if your mother is dead) my mother was a good woman.
True	False	26.	I love my mother, or (if your mother is dead) I loved my mother.
True	False	27.	Talking over problems and worries with someone is often more helpful than taking drugs or medicine.

APPENDIX C: INFREQUENCY ITEMS

Infrequency Items

Instructions: If the statement is **true** or **mostly true**, as applied to you, click true (T). If a statement is **false** or **not usually true**, as applied to you, click false (F).

True	False	1.	There have been a number of occasions when people I know have said to hello to me.
True	False	2.	I cannot remember a single occasion when I have ridden on a bus.
True	False	3.	I find that I often walk with a limp which is the result of a skydiving accident.
True	False	4.	There have been times when I have dialed a telephone number only to find that the number was busy.
True	False	5.	I visited Easter Island last year.
True	False	6.	I go at least once every two years to visit either northern Scotland or some parts of Scandinavia.
True	False	7.	Sometimes I feel sleepy or tired.
True	False	8.	On some occasions I have noticed that some other people are better dressed than myself.

APPENDIX D: ABBREVIATED MARLOWE-CROWN SOCIAL DESIRABILITY SCALE

Abbreviated Marlowe-Crowne Social Desirability Scale

Instructions: If the statement is **true** or **mostly true**, as applied to you, click true (T) If a statement is **false** or **not usually true**, as applied to you, click false (F).

True	False	1.	It is sometimes hard for me to go on with my work if I am not encouraged.
True	False	2.	I sometimes feel resentful when I don't get my way.
True	False	3.	On a few occasions, I have given up doing something because I thought too little of my ability.
True	False	4.	There have been times when I felt like rebelling against people in Authority even though I knew they were right.
True	False	5.	No matter who I'm talking to, I'm always a good listener.
True	False	6.	There have been occasions when I took advantage of someone.
True	False	7.	I'm always willing to admit it when I make a mistake.
True	False	8.	I sometimes try to get even rather than forgive or forget.
True	False	9.	I am always courteous, even to people who are disagreeable.
True	False	10.	I have never been irked when people expressed ideas very different from my own.
True	False	11.	There have been times when I was quite jealous of the good fortune of others.
True	False	12.	I am sometimes irritated by people who ask favors of me.
True	False	13.	I have never deliberately said something that hurt someone's feelings.

APPENDIX E: ABBREVIATED SCHIZOTYPAL PERSONALITY QUESTIONNAIRE

Abbreviated Schizotypal Personality Questionnaire (SPQ-B)

Instructions: Please answer each item by circling (Yes) or (No). Answer **all** items even if unsure of your answer. When you have finished, check over each one to make sure you have answered them all.

Yes	No	1.	People sometimes find me aloof and distant.
Yes	No	2.	Have you ever had the sense that some person or force is around you, even though you cannot see anyone?
Yes	No	3.	People sometimes comment on my unusual mannerisms and habits
Yes	No	4.	Are you sometimes sure that other people can tell what you are thinking?
Yes	No	5.	Have you ever noticed a common event or object that seemed to be a special sign for you?
Yes	No	6.	Some people think that I am a very bizarre person.
Yes	No	7.	I feel I have to be on my guard even with friends.
Yes	No	8.	Some people find me a bit vague and elusive during a conversation.
Yes	No	9.	Do you often pick up hidden threats or put-downs from what people say or do?
Yes	No	10.	When shopping do you get the feeling that other people are taking notice of you?
Yes	No	11.	I feel very uncomfortable in social situations involving unfamiliar people.
Yes	No	12.	Have you had experiences with astrology, seeing the future, UFOs, ESP or a sixth sense?
Yes	No	13.	I sometimes use words in unusual ways.
Yes	No	14.	Have you found that it is best not to let other people know too much about you?
Yes	No	15.	I tend to keep in the background on social occasions.
Yes	No	16.	Do you ever suddenly feel distracted by distant sounds that you are not normally aware of?
Yes	No	17.	Do you often have to keep an eye out to stop people from taking advantage of you?
Yes	No	18.	Do you feel that you are unable to get "close" to people?
Yes	No	19.	I am an odd, unusual person.
Yes	No	20.	I find it hard to communicate clearly what I want to say to people.
Yes	No	21.	I feel very uneasy talking to people I do not know well.
Yes	No	22.	I tend to keep my feelings to myself.

APPENDIX F: TABLE

Table 1:
Correlations between Delusion Measure, Schizotypy Measures, Paranoid Dimension Measure, and Stroop Contrast Scores

	PDI-21	SPQ-B	PPD	SPD	In/C AC	In/N AC	In/C RT	In/N RT
PDI-21	1							
SPQ-B	.60**	1						
PPD	.53**	.59**	1					
SPD	.51**	.45**	.70**	1				
In/C AC	-.31	-.31	-.42*	-.15	1			
In/N AC	-.33	-.12	-.31	-.14	.76**	1		
In/C RT	.41**	.07	.07	.17	-.12	-.20	1	
In/N RT	.26	-.03	-.04	.10	-.10	-.20	.86**	1

N = 35

Values are Pearson correlations; significance is two-tailed; * Statistically significant $p < .05$, **Statistically significant $p < .01$; PDI-21 = Peters' et. al Delusion Inventory (21-item); SPQ-B = Abbreviated Schizotypal Personality Questionnaire; PPD = Dimensional score from the Paranoid Personality Disorder Section of the Structured Clinical Interview for DSM-IV Axis II Personality Disorders; SPD = Dimensional score from the Schizotypal Personality Disorder Section of the Structured Clinical Interview for DSM-IV Axis II Personality Disorders; In/C AC = Incongruent -Congruent Accuracy Contrast score from the Stroop task; In/N AC = Incongruent -Neutral Accuracy Contrast score from the Stroop task; In/C RT = Incongruent -Congruent Reaction Time Contrast score from the Stroop task; In/N RT = Incongruent –Neutral Reaction Time Contrast score from the Stroop task.

APPENDIX G: FIGURES

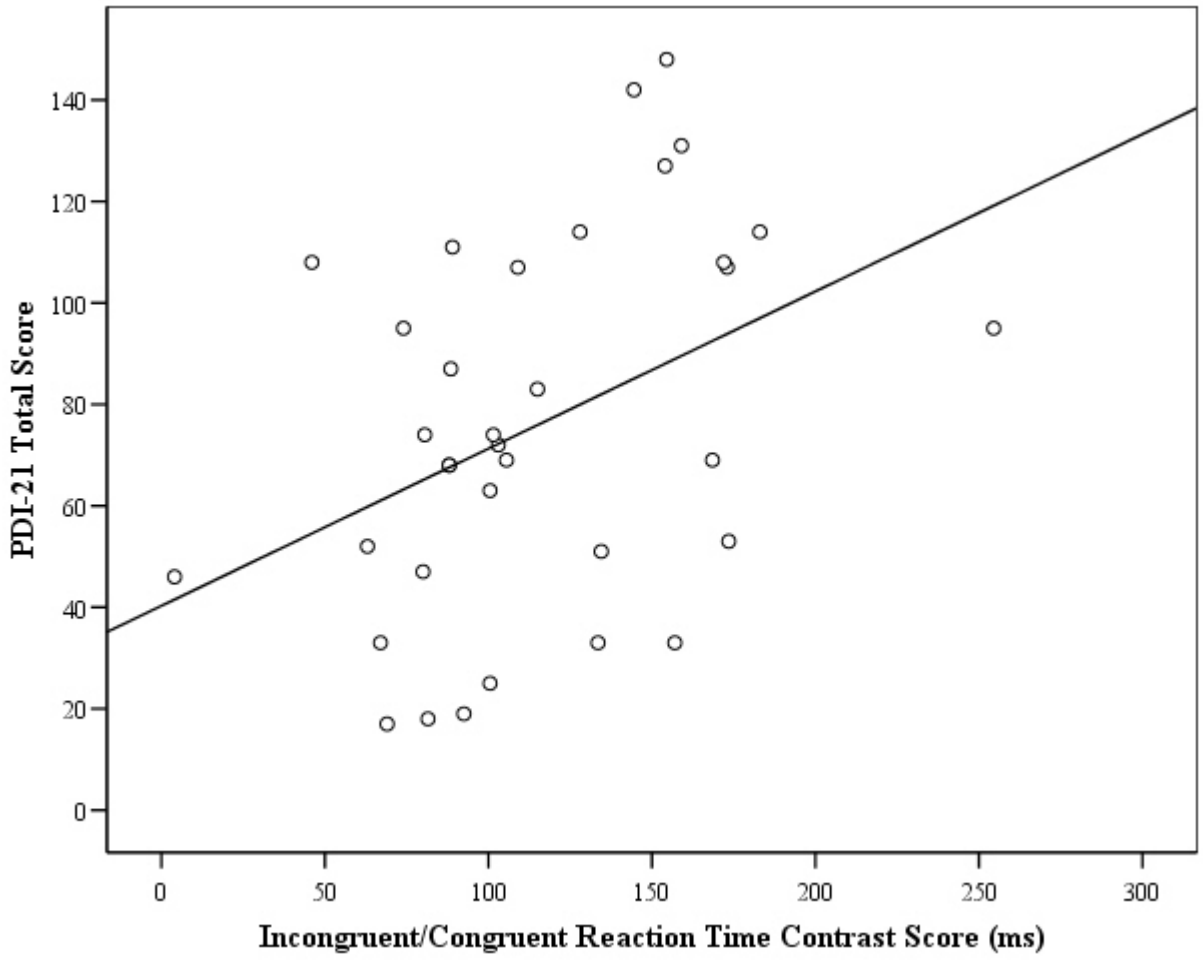


Figure 1: Correlation between Incongruent/Congruent Contrast and PDI-21 Score

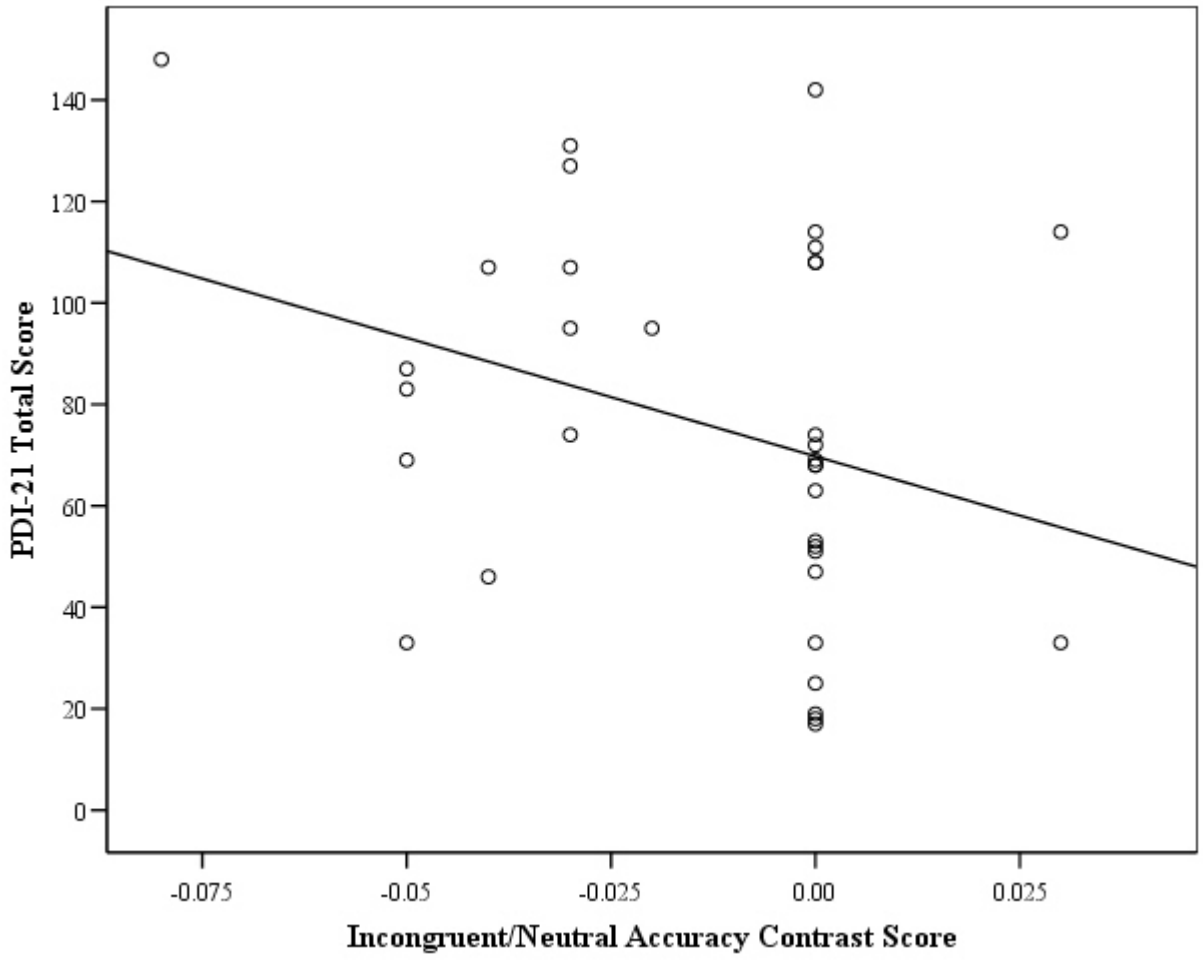


Figure 2: Correlation between Incongruent/Neutral Accuracy Contrast and PDI-21 Score

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