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Affective dysfunction and affective interference in schizotypy

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AFFECTIVE DYSFUNCTION AND AFFECTIVE INTERFERENCE IN SCHIZOTYPY

A Thesis Defense

Submitted to the Graduate Faculty of
Louisiana State University and
Agricultural and Mechanical College
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Abstract

Affective dysfunction is a core feature of schizophrenia spectrum disorders. Schizophrenic and schizotypal participants report higher levels of unpleasant and lower levels of pleasant trait affect than controls. In response to pleasant stimuli, though, participants often report similar levels of pleasant emotion to controls, but heightened unpleasant emotion, suggesting pleasant experiences may be affected by intrusive unpleasant emotion. An emotional Stroop task was used to examine the relationship between affective interference and trait affect in schizotypy. No significant differences were found between schizotypal participants and controls on e-Stroop performance, but schizotypal participants did self-report more unpleasant trait affect and less pleasant trait affect than controls. Of the schizotypy symptom dimensions, only cognitive disorganization was significantly correlated with unpleasant interference on the e-Stroop. Self-reported trait affect was not correlated with e-Stroop performance, but unpleasant trait affect was correlated with positive schizotypy symptoms and pleasant trait affect was inversely correlated with negative symptoms. Results suggest avenues for future exploration of unpleasant trait bias and cognitive dysfunction in schizophrenia-spectrum disorders.

Introduction

This study examines the underlying mechanisms of affective dysfunction in schizotypy by measuring and comparing affective interference during an emotional Stroop task and self-reported trait pleasant and unpleasant affectivity. The introduction begins with a brief overview of schizophrenia and its heterogeneous symptom factors (e.g., positive, negative, and disorganized), and schizotypy as a theoretical construct providing a developmental framework for the study of schizophrenia and its symptom structure. The introduction then goes on to discuss affective dysfunction in schizophrenia and schizotypy in more detail, and questions that have been raised about its underlying nature. Finally, the introduction will apply the emotional Stroop paradigm to explore a potential underlying cognitive mechanism of subjectively-experienced trait emotional dysfunction in schizotypy.

Schizophrenia

Schizophrenia is a massively debilitating mental disorder, with lifetime population prevalence estimates ranging from .5 to 1%, and estimates of economic and societal burdens exceeding those of most other physical and mental illnesses (Lenzenweger, 2006; Bhugra, 2005). Schizophrenia is characterized by the presence of two or more of the following symptoms: delusions, hallucinations, disorganized speech, grossly disorganized or catatonic behavior, and negative symptoms (i.e., affective flattening, alogia, or avolition). Typical age of onset ranges from late teens to mid-30s, with onset prior to adolescence very rare (American Psychiatric Association, 2000).

Heterogeneity Within Schizophrenia. Schizophrenia is a heterogeneous disorder, with clinical symptom presentation varying widely across individuals within the disorder (e.g., Dolfus, 1997; Tsuang, Lyons, & Faraone, 1990). Researchers have failed to

identify a single disease process or neurological markers distinct to all schizophrenia patients. In addition, various genetic and environmental risk factors identified thus far do not occur systematically among patients.

These factors have led researchers to develop various heterogeneous classification systems for the disorder. These classification systems have been either based on the assumption that schizophrenia actually consists of multiple disease entities, or that schizophrenia is a single disorder that comprises discrete sign and symptoms complexes with independent processes (Buchanan & Carpenter, 1994). The Diagnostic and Statistical Manual, Fourth Edition, Text Revision (DSM-IV-TR; 2000) separates the disorder into distinct disease entity subtypes of paranoid, disorganized, catatonic, undifferentiated, and residual. Several other classification systems focusing on distinct disease entities have been proposed over time, including separately classifying patients based on developmental patterns of the disease (early versus late onset, quality of premorbid adjustment, etc.) (Farmer, McGuffin, & Spitznagel, 1983; Herron & Diamond, 1991). Alternatively, classification systems have emerged that focus on presentation of predominantly positive versus predominantly negative symptom clusters (i.e., negative v. positive schizophrenia, type I and type II schizophrenia, deficit v. nondeficit schizophrenia (Andreasen, 1982; Andreasen & Olsen, 1982; Buchanan & Carpenter, 1994; Crow, 1985; Carpenter, Heinrichs, & Alphas, 1988; Fenton, 2000)). This approach to classification of heterogeneous presentations of the schizophrenia syndrome dates back to the theoretical recognition by Kraepelin (1919) that there were two processes that characterized schizophrenia: (1) trait-negative symptoms, which Kraepelin referred to as “avolitional syndrome,” and (2) “loss of inner unity of activities of intellect, emotion, and volition” (see Buchanan & Carpenter, 1994,

generally for a discussion of the development of the symptom cluster approach to schizophrenia subtype categorization).

A more recent taxonomy focusing on symptoms clusters that has considerable support separates heterogeneous symptoms of schizophrenia into three empirically derived and validated factor domains representing positive, negative, and disorganization symptom complexes (see Buchanan & Carpenter, 1994, for a review of factor-analytic studies resulting in this general symptom cluster organization model). Positive symptoms include delusions, hallucinations, and inappropriate affect; negative symptoms include blunted affect, anhedonia, avolition, apathy, and alogia; and disorganization symptoms include inappropriate affect, and disorganized speech and behavior. These heterogeneous organizational approaches have led to a paradigmatic shift from the study of schizophrenia as a unitary concept toward the study of the individual symptom dimensions within the disease.

Schizotypy as a Developmental Framework for Schizophrenia

Meehl (1962, 1990) proposed a developmental theory of schizophrenia spectrum disorders. This theory posits that some form of genetic aberration leads to dysfunction in the synaptic control system in the central nervous system (CNS), which he termed “hypokrisia,” characterized by insufficient discrimination in neural transmissions. Meehl originally theorized a single-gene influence, which has not been supported by genetic research; but research suggests that a mixed polygenetic model continues to be plausible (Lezenwegger, 2006). This dysfunctional pattern of poorly controlled neural transmission causes “cognitive slippage,” producing a CNS anomaly he termed “schizotaxia,” which is estimated to occur in 10% of the population. In individuals with schizotaxia, social environmental learning factors contribute to the development of “schizotypy,” which refers to a latent psychological and personality

organization resembling symptoms of schizophrenia in an attenuated form along a spectrum of dysfunction (e.g., odd beliefs, social anhedonia) (Brown et. al, 2008; Kerns, 2005). According to Meehl's model, nearly all schizotaxic individuals will develop schizotypy in most social environments. However, it should be noted that use of the term "schizotypy" in this manner does not refer to schizotypal personality disorder, or any other specific disorder diagnosable by the DSM-IV-TR.

From this developmental point of schizotypy, it is theorized that the effects of certain trait personality dimensions, such as social introversion and anxiety (termed "polygenetic potentiators"), and other physical and psychological environmental stressors, combine to determine the manifest expression of schizotypic vulnerability. This manifest expression can range from the presence of endophenotypic markers of schizotypy (such as attention deficits, eye tracking dysfunction, or statistical deviance on certain psychological questionnaires) without display of symptoms meeting criteria for a clinically-diagnosable psychological disorder; to an intermediate level of schizotypic psychopathology (such as schizotypal or paranoid personality disorder); to clinically-diagnosable schizophrenia. It is proposed under this model that development of schizophrenia in a psychosis-vulnerable schizotypic individual may be potentiated by some form of "second hit," such as in utero effects of maternal influenza, toxoplasmosis, or other teratogenic exposure. However, which specific developmental stressors might influence the expression of schizophrenia or the mechanism by which they might assert their effects is not yet well-understood (Brown, Silva, Myin-Germeys, Lewandowski, & Kwapil, 2008; Kerns, 2006; Lezenwegger, 2006; Meehl, 1990).

Thus, Meehl's model hypothesizes that the presence of schizotypy indicates vulnerability to clinical schizophrenia-spectrum disorders. This connection between schizotypy

and schizophrenia has been supported by longitudinal research indicating that a higher proportion of schizotypic individuals identified through psychometrically elevated scores on measures of certain sub-clinical perceptual, cognitive, and social aberrations go on to develop schizophrenia-spectrum disorders compared to control participants (Chapman, L.J., Chapman, J.P., Kwapil, Ecklad, & Zinser, 1994). Accordingly, the study of schizotypy offers a strategically beneficial approach to understanding schizophrenia. It provides a means to explore premorbid endophenotypic indicators and polygenetic and environmental potentiators of schizophrenia development (Gooding & Tallent, 2003). Moreover, it allows exploration of dimensions of schizophrenia dysfunction, albeit in a diminished form, in a “relatively pure context” (Mohanty et al, 2005, p. 17) free of the confounding variables of medication, cognitive and personality deterioration, and institutionalization (Lezenwegger, 2006; Mohanty et al, 2005).

Heterogeneity Within Schizotypy. Factor analyses have confirmed a three-factor symptom structure in schizotypy that parallels the heterogeneous nature of schizophrenia, consisting of positive, negative, and disorganized symptom clusters (Brown et al., 2008; Kerns, 2006). This factor structure is consistent with the theory that schizotypy may indicate a vulnerability to development of schizophrenia-spectrum disorders. It is cautioned that, as with symptom clusters in schizophrenia, these symptom clusters frequently co-occur to varying degrees in individuals with schizotypy, and thus do not represent mutually-exclusive sub-categories (Brown et al., 2008). It is more appropriate to conceptualize individuals with schizotypy as exhibiting varying degrees of each symptom dimension—positive, negative or disorganized—and not as belonging to categorical homogenous sub-groups of individuals with “positive schizotypy,” “negative schizotypy,” and “disorganized schizotypy.”

Analysis of Affective Experience

Affect is a broad construct, referring generally to the experience of emotion, either pleasant or unpleasant, with varying levels of intensity, arousal, duration, and triggers or patterns of activation. Negative (or unpleasant) affectivity refers to a dispositional tendency to experience aversive emotional states; to perceive the world as threatening, problematic, and frustrating; and to demonstrate heightened reactivity to stress. Positive (or pleasant) affectivity refers to a dispositional tendency to experience pleasant or rewarding emotional states, willingness to actively engage in the environment, and low reactivity to unpleasant stimuli. (Horan, & Blanchard, 2003; Watson & Tellegen, 1985). These states are orthogonal, particularly when experienced at low intensity levels (Humrichouse, Chmielewski, McDade-Montez, & Watson, 2007; Watson, 1988; Watson, Wiese, Vaidya & Tellegen, 1999). Use of the terms “positive” and “negative” with regard to affectivity is wholly distinct from use of “positive” and “negative” symptoms in schizophrenia and schizotypy, which refer to the presence of abnormal perceptions and cognitions such as hallucinations and delusions, and the absence of healthy levels of motivation and social behavior, respectively. Although the emotion literature generally discusses affectivity using “positive” and “negative” terminology, in order to distinguish reference to affect from reference to symptom clusters, this paper will use the terms “pleasant affect” and “unpleasant affect” to discuss emotional valence. According to certain models of emotion, such as the circumplex model, emotional stimuli material can also be categorized across two separate underlying dimensions: valence and arousal (e.g., Clark-Foos & Marsh, 2008; Kring, Barrett, & Gard, 2003). Valence refers to the effect of a stimulus in evoking pleasant or unpleasant affect. Arousal refers to the degree to which a stimulus evokes an exciting versus calming reaction. The valence-arousal circumplex model has been found to be

applicable to understanding emotional experience in schizophrenic populations (Kring, et al., 2003).

The experience of emotions is theorized to involve an interactive relationship between behavioral, somatic, and cognitive factors (Humrichouse, et al., 2007; Lambie & Marcel, 2002; Wilson & MacLeod, 2007). Research of cognitive factors related to emotion generally focuses on either the subjective content associated with different emotions, or the individual differences in styles of selective information processing that may give rise to such cognitive content. This study will address both of these cognitive aspects of emotion in schizotypy by examining and comparing individuals' explicit subjective perceptions of the valence of their own trait affectivity, and a more implicit measure of cognitive affective interference due to word valence (isolated from word arousal effects). Many cognitive accounts of emotional dysfunction are premised on the theory that these two cognitive aspects of emotion are related, such that increased vulnerability to unpleasant emotions is associated with a selective encoding bias favoring unpleasant information. The degree to which emotional stimuli interfere with performance on a central task, which presents the emotional nature of stimuli as irrelevant (i.e., an "interference task"), is taken as an index of encoding bias. The most commonly used emotional interference task is the emotional Stroop (Wilson & MacLeod, 2007).

The Emotional Stroop Paradigm. The original color Stroop task (Stroop, 1935) is a cognitive task requiring participants to indicate the color ink in which a color word is printed. It measures executive resources expended in the inhibition of a prepotent response (i.e., reading a printed word) in favor of a less dominant required response (i.e., stating the ink color) when these two response choices are in conflict. For congruent trials, the color of the ink is consistent with the printed color word (e.g., the word "red" is printed in red ink); for incongruent

trials, the color of the ink is inconsistent with the printed color word (e.g., the word “red” is printed in blue ink). Thus, a congruent trial is one in which values from the two salient dimensions (ink color and semantic meaning of the word) are associated with the same task-appropriate response, and an incongruent trial is one in which one dimension (e.g., ink color) is associated with one task-appropriate response and other (e.g., semantic word meaning) is associated with a different task-appropriate response, thereby creating a conflict that must be resolved before the correct response (ink color) is generated (Algom, Chajut, & Lev, 2004). In the classic color Stroop model, the “Stroop effect” is measured as the response time to indicate ink color for the incongruent trials compared to the baseline response time for congruent trials of the same color word (e.g., Algom, et al., 2004; Larsen, Mercer, & Balota, 2006). The magnitude of this Stroop effect indicates the amount of difficulty experienced by participants in focusing exclusively on the target dimension of color in the incongruent trials due to the fact that the participant’s attention is also drawn to the competing and conflicting task-irrelevant dimension of semantic word meaning (Algom, et al., 2004). The traditional Stroop task has been termed the “gold standard” of attentional measures (MacLeod, 1992).

The emotional Stroop task is an adaptation of this traditional Stroop task that has been used to examine affective interference caused by emotionally salient words as an indication of attentional bias. In this task, reaction time to indicate the color in which emotionally salient words are printed (i.e., “emotional” trials) is compared to reaction time to indicate the color in which emotionally neutral words are printed (i.e., “neutral” trials) (e.g., Larsen, et al., 2006). It should be noted that while the label “emotional Stroop” has been consistently used throughout the literature for this task, likely due to the facial similarity between the two paradigms, researchers have pointed out that the emotional Stroop task (hereinafter “e-Stroop”) is not

actually a true Stroop task. The classic Stroop conflict between congruence and incongruence of the two attention-drawing dimensions (i.e., color and semantic word meaning) is not present in the e-Stroop task, as the ink color and semantic word meanings bear no direct relationship to each other in the e-Stroop task (Algom, et al., 2004; Larsen, et al., 2006). Instead, in the e-Stroop task the difference in reaction time to respond to emotional and neutral words is assumed to represent affective interference due to the salience of the semantic content of the emotional words, reflecting an attentional bias to the affective component of the emotional stimuli. (Andersson, Bakhsh, Johansson, Kaldø, & Carlbring, 2005; Cohen, Dunbar, & McClelland, 1990).

Healthy adults have been shown to demonstrate a bias toward unpleasant words on the e-Stroop (van Hoof, Dietz, Sharma, & Bowman, 2007; McKenna & Sharma, 1995). Therefore, to some extent, a bias toward unpleasant stimuli is present across the general population. However, differences in trait personality characteristics among healthy adults are related to the level of affective interference demonstrated—individuals high in pessimism demonstrate a larger bias toward unpleasant words than individuals high in optimism, but no bias toward pleasant words; whereas individuals high in optimism demonstrate only a slight bias toward unpleasant words (thought to be adaptive), and a significantly higher bias toward positive words (Segerstrom, 2001). This pattern of affective bias in healthy adults can also be experimentally manipulated through both subliminal and social priming. In one experiment reported by Smith and colleagues (2006), participants were subliminally primed with either unpleasant or pleasant words, or were not primed. Those who were primed with unpleasant words and those who were not primed demonstrated a bias toward unpleasant words on a subsequent e-Stroop task; but this bias was not evident when the e-Stroop task was preceded by

the positive priming condition. In another experiment described in this study, participants interacted with either a “nice” or a “mean” experimenter. In the mean experimenter condition, participants demonstrated a bias toward unpleasant words on the e-Stroop task, and in the nice experimenter condition participants demonstrated a bias toward pleasant words.

The e-Stroop has been used most widely, though, to study individual differences across various pathologies (see Williams, Mathews, & MacLeod, 1996, for a review of studies using the e-Stroop paradigm to examine affective bias in anxiety and depressive disorders). Studies utilizing the e-Stroop test have repeatedly found that individuals with social phobia name the ink color of social threat words more slowly than neutral words (Amir et al., 1996; Hope, Rapee, Heimberg, & Dombek, 1990; Lundh & Ost, 1996; Maidener, Chen, Draske, Bohn, & Bystritsky, 1996). The e-Stroop has been used in studies comparing individuals with eating disorders to controls on interference for body- and food-related words (Johansson, Carlberg, Ghaderi, & Andersson, 2008); and comparing individuals with borderline personality disorder to controls (Domes, Winter, Schnell, Vohs, Fast, & Herpertz, 2006). It has been used to examine the effects of sleep deprivation (Sagaspe, Sanchez-Ortuno, Charles, Taillard, Valtat, Bioulac, et al., 2006). In addition, e-Stroop studies have demonstrated bias to smoking-related and affective words among smokers (Drobes, Elibero, & Evans, 2006), and bias to pain words among individuals with chronic pain disorder (Crombez, Hermans, & Adriaensen, 2000). In fact, the e-Stroop task has been referred to as the “most popular” of the paradigms adapted from experimental cognitive psychology by researchers investigating the influence of cognitive mechanisms in emotional disorders (Andersson et al., 2005, p. 32).

Recent Issues Regarding Structure of the Emotional Stroop. Recent research, however, calls into question the proper interpretation of results of prior e-Stroop studies, which

might be confounded by other lexical factors that may drive reaction time differences between emotional and neutral words. A 2006 meta-analysis by Larsen, Mercer, and Balota compared emotional word stimuli to neutral word stimuli used in 32 prior e-Stroop studies, using statistics provided by the English Lexicon Project (ELP) database (Balota, et al., 2007), which is a large, searchable database of lexical characteristics for over 40,000 words. The ELP database includes statistics on frequency with which a word is used, orthographic neighborhood size (the number of words into which a single word can be transformed by changing only one letter in the word), length, and syllables, all of which have been shown to affect reaction time to make a word-versus-nonword lexical decision. Larsen and colleagues (2006) found significant differences among unpleasant, neutral, pleasant, and disorder-specific words used in these prior studies on measures of frequency, orthographic neighborhood, and length. Both unpleasant and pleasant words were significantly longer and had significantly smaller orthographic neighborhoods than neutral words, and unpleasant words were significantly rarer than neutral words. After controlling for these confounding lexical factors, reaction time differences between unpleasant words and neutral words found in prior studies disappeared, and only reaction time for disorder-specific words remained significantly longer than reaction time for neutral words. Therefore, the authors stressed that “it is absolutely critical that the emotional and neutral words be matched on lexical features known to influence word recognition, especially frequency of word use” if e-Stroop performance is to be appropriately used to draw inferences about affective reactivity (Larsen, et al., 2006, p. 67; see also Kahan & Hely, 2008).

Affective Dysfunction in Schizophrenia and Schizotypy. Dysfunction of affective experience has been a central defining feature of schizophrenia. Compared to control participants, schizophrenia patients consistently self-report higher levels of unpleasant and lower

levels of pleasant trait affectivity (Blanchard, Mueser, & Bellack, 1998; Horan & Blanchard, 2003a; Horan & Blanchard, 2003b; Horan, Blanchard, Clark, & Green, 2008; Horan, Brown, & Blanchard, 2007; Horan, Kring, & Blanchard, 2006). The pattern of unpleasant trait affectivity appears stable across different clinical states (Blanchard, Horan, & Brown, 2001), and is consistent with studies utilizing more naturalistic experience sampling methodology, which have found schizophrenia patient reports of lower levels of pleasant emotion and higher levels of unpleasant emotion than control participants in their daily lives (Myin-Germeys, Delespaul, & deVries, 2000; Myin-Germeys, van Os, Schwartz, Stone, & Delespaul, 2001).

Increased unpleasant trait affectivity is also found in schizotypy (Lewendowski et al., 2006; Phillips & Seidman, 2008), which has been recognized as consistent with Meehl's description of "aversive drift" (an intense, pervasive, and increasing tendency for a schizotypal individual to experience unpleasant emotions) (Horan, et al., 2007). Lewandowski, et al. (2006) found that unpleasant affect (quantified using depression and anxiety measurements) is associated with both positive and negative schizotypy symptoms, but demonstrates a stronger association with positive symptoms.

Affective dysfunction has important functional implications in schizophrenia and schizotypy. For example, affective dysfunction is closely tied to social anhedonia, a promising endophenotype also found in first-degree relatives with schizophrenia and correlated with several neuropsychological deficits, which implicates possible genetic and neurological components of schizophrenia risk (Cohen, Leung, Saperstein, & Blanchard, 2006; Horan, et al., 2007). Social anhedonia has been consistently found to significantly correlate with higher levels of self-reported unpleasant trait affectivity and/or lower levels of self-reported pleasant trait affectivity (Blanchard, et al., 1998; Gooding, Davidson, Putnam, & Tallent, 2002; Kerns, 2005). Studies

have demonstrated a connection between anhedonia in schizotypy and heightened risk for later development of schizophrenia spectrum disorders (Gooding, Tallent, & Matts, 2005; Horan, et al., 2007; Kwapil, 1998; Kwapil, Miller, Zinser, Chapman, & Chapman, 1997).

Discrepancies Reported in Affective Dysfunction Across Experimental

Paradigms. Interestingly, it has been consistently demonstrated that while schizophrenia patients reliably report higher levels of unpleasant and lower levels of pleasant trait affectivity than control participants, and higher levels of social and physical anhedonia, individuals with schizophrenia generally report levels of pleasant emotion similar to that of controls in immediate response to evocative stimuli in the laboratory or in their daily lives (assessed by experience sampling methodology) (see Cohen & Minor (in press) for a meta-analysis of hedonic reactivity among schizophrenia patients in laboratory studies; see also Gard, Kring, Gard, Horan, & Green, 2007; Herbener, Rosen, Khine, & Sweeney, 2007; Horan, Kring, & Blanchard, 2006; Kring, 1999). Thus, lower levels of pleasant trait affectivity self-reported by schizophrenia patients do not correspond to self-reports of patients' affective state responses to pleasurable stimuli in the laboratory. This discrepancy has raised questions about the nature of affective dysfunction in the disorder.

Horan, Green, Kring, and Nuechterlien (2006) examined possible explanations for the inconsistency between self-report of trait anhedonia and reported affective response to evocative stimuli in a laboratory setting. They found that the discrepancy is likely not due to faulty short term memory for pleasant emotional experiences, as there were no significant differences in schizophrenia patient report of pleasant emotion experienced during exposure to pleasant or neutral film clips or food items following a four hour delay. However, the patients did report slightly but significantly higher levels of unpleasant emotions during the recall task

than control participants. This result led the researchers to suggest that “schizophrenia might be associated with deficient appetitive pleasure and/or pleasurable experiences that are ‘contaminated’ by co-occurring elevations of [unpleasant] emotions” (p. 506).

This theory is supported by Cohen & Minor’s (in press) recent meta-analysis of studies examining hedonic reactivity of schizophrenia patients in a laboratory setting, which found that although patients did not differ from control participants in subjective pleasant affective reactions to evocative stimuli, patients did report relatively strong co-occurring aversion to both pleasant and neutral stimuli (see also Earnst & Kring, 1999; Kring, Kerr, Smith, & Neale, 1993; Kring & Neale, 1996). Additionally, Cohen, St-Hillaire, Aakre, & Docherty (2009) found that schizophrenia patients with clinically rated anhedonia, compared to other patients and controls, showed a dramatic increase in unpleasant emotion expression when discussing pleasurable memories, but no corresponding decrease in pleasant emotions. In light of these findings, the subjective experience of anhedonia may actually be driven by pervasive activation of invasive unpleasant affect during pleasant experiences, due to an unpleasant affectivity bias that is insufficiently inhibited by executive resources (as discussed in greater detail below). Thus, it might be that self-reported emotional dysfunction in schizotypy and schizophrenia is related to the disruption of in-the-moment mood by a constant experience of intrusive unpleasant affect, even in situations where pleasant affect would be expected to dominate the subjective experience of mood.

Another mechanism by which unpleasant affective bias might contribute to more generalized unpleasant trait affect could be by tainting more abstract representations of past pleasant experiences, thereby leading to biased memories and deficits in motivation to seek out future pleasant experiences. Heerey and Gold (2007) found that schizophrenia patients

demonstrate deficits in the ability to translate subjective experience of pleasant or aversive qualities of evocative stimuli (“liking”) into motivated behavior indicating desire to revisit or avoid the stimuli in the future (“wanting”), particularly when patients must rely on internal abstract representation of the stimuli to make such behavioral decisions. These researchers compared subjective “liking” of emotionally-evocative or neutral photographs in patients and controls, measured as self-report of the hedonic value of the photographs, to participants’ rapid key-pressing behavior indicating desire to either continue or discontinue exposure in the presence of the stimulus, and key-pressing behavior indicating desire to see or not to see such photos again measured in the absence of the stimulus. They found that there were no differences between patients and controls in self-reported valence of the stimuli. The valence rating scale used in this study was bipolar, ranging from unpleasant to pleasant, though, which may reflect patients’ appreciation of pleasant experience as similar to controls while neglecting to capture what other studies have found to be a co-occurring elevation of unpleasant affect when faced with pleasant stimuli when using separate unipolar measures (cited above). Patients did, however, demonstrate deficits in their ability to couple key-pressing behavior to stimulus valence, particularly where motivated behavior required participants to respond to an internally-generated abstract stimulus representation (“representational responding”). This lack of correspondence between representational responding and patients’ report of stimulus variance in its presence was associated with self-reported social anhedonia. The researchers concluded that these results “provide evidence that schizophrenia involves a failure to accurately use representations of motivational salience to guide behavior” (p. 275). Working memory deficits were associated with this motivational deficit, accounting for 9% of the variance in correspondence between stimulus valence and representational responding (Heerey & Gold,

2007; see also Gold, Waltz, Prentice, Morris, & Heerey, 2008). Although not examined by Heerey and Gold (2007), this paper speculates whether persistent invasive negative affect also plays a role in disrupting the motivational salience of a stimulus when patients must rely on internal abstract representation of past positive experiences to make more global determinations about trait hedonic experience.

While the conceptualization of intrusive negative affect contributing to affective dysfunction by tainting positive experiences has recently begun to be explored in schizophrenia, there is a dearth of studies teasing this concept apart in schizotypy. The possibility that pleasant experiences may be contaminated by interference of co-occurring unpleasant affectivity in schizotypy is explored in the present study through measurement of affective interference on a laboratory-based e-Stroop task. Understanding this process in schizotypy could contribute to understanding potential mechanisms underlying the more functionally debilitating affective symptoms in schizophrenia.

Affective Interference and Executive Dysfunction in Schizophrenia and Schizotypy. Executive Dysfunction in Schizophrenia and Schizotypy. As discussed above, the e-Stroop task paradigm is framed by the proposition that executive control network resources are strained by affective interference triggered by certain emotionally-valenced words, thereby resulting in increased reaction time required to ignore the semantic content of the word and state the ink color in which it is printed. In studies using other methodology, schizophrenia patients have been shown to demonstrate executive control deficits, which suggest that such patients have difficulty resolving multiple simultaneous response conflicts (Gooding, Bran, & Studer, 2006). Studies utilizing the Wisconsin Card Sorting task have demonstrated that these executive functioning deficits contribute specifically to interpersonal behavior dysfunction among

schizophrenia patients (Bowie et al., 2008); and executive functioning, combined with delayed verbal memory scores, have been shown to contribute over a quarter of the variance in community social functioning, beyond the effects of symptom severity and general cognitive functioning (Cohen, Forbes, Mann, & Blanchard, 2005). In schizotypy, deficits in prepotent inhibition (i.e., inhibition of a contextually inappropriate but highly automatic or prepotent response), as measured by tasks including the color Stroop task, have been shown to be specifically related to disorganization symptoms (Kerns, 2006). This paper uses the e-Stroop paradigm to explore affective interference thought to be related to such executive control deficits.

Exploration of Emotional Stroop Effects in Schizophrenia and Schizotypy. The e-Stroop paradigm has only been used in a handful of studies exploring affective interference and executive dysfunction in schizophrenia-spectrum disorders. In large part, these studies have focused on attentional bias toward threat-related words by schizophrenia patients of the paranoid subtype suffering from delusions of persecution (Bentall & Kaney, 1989; Epstein, Stern, & Silbersweig, 1999; Fear, Sharp, & Healy, 1996; Kinderman, Prince, Waller, & Peters, 2003; Leafhead, Young, & Szulecka, 1996). More recently, Strauss and colleagues (2008) found that schizophrenia patients with chronic primary negative symptoms (i.e., “deficit syndrome” patients) displayed less attentional bias for happiness words on an emotional Stroop test than patients without chronic negative symptoms or controls. (However, this decreased attentional bias manifested as a shorter reaction time for happiness words compared to control words. This result could alternatively be interpreted as a facilitation effect, revealing an automatic attempt to avoid the emotional salience of the word by indicating ink color choice as quickly as possible to make the current word disappear from the screen (Andersson et al., 2006)). Although deficit

patients did not show increased attentional bias for unpleasant emotion words (anger, anxiety, and sadness words), they did display a significantly greater “lingering” effect for unpleasant emotion words than non-deficit patients or controls, assessed using a modified e-Stroop paradigm wherein emotional words are followed by neutral words, with increased reaction time for the neutral word immediately following the emotional word indicating carryover attentional disruption. However, these findings are not directly applicable to the present investigation, as the deficit/non-deficit symptom classification model used is not directly analogous to the three-factor positive/negative/disorganized symptom cluster model. The primary negative, or deficit, symptoms that were the focus of the study (i.e., not based on secondary negative symptoms due to the influence of medication, depression, anxiety, or paranoia) create a narrower symptom category than that represented by the negative symptom cluster in the three-factor model used herein (e.g., Horan & Blanchard, 2002).

Two studies have recently examined affective interference in schizotypy (Mohanty et al., 2008; Von Strein & Van Kampen, 2009). Mohanty and colleagues (2008) measured positive and negative schizotypy symptoms using the perceptual aberration, magical ideation, physical anhedonia, and social anhedonia subscales of the Chapman scales for psychosis proneness (Chapman, L.J., Chapman, J.P., & Raulin, 1978; Chapman, L.J., Chapman, J.P., & Raulin, 1976; Eckblad & Chapman, 1983), and the Von Strein group (2009) measured positive symptoms using the Schizotypic Syndrome Questionnaire (Van Kampen, 2006), a measure derived from the Chapman scales. These studies found that positive schizotypy symptoms, but not negative schizotypy symptoms in the Mohanty (2008) study, were associated with affective interference on the e-Stroop test for unpleasant words only. Interference from unpleasant words in the Mohanty (2008) study was not directly associated with self-reported

anhedonia levels, however, but was instead positively correlated with positive symptoms. This result is consistent with Lewandowski's (2006) finding that depression and anxiety scores demonstrated a stronger correlation with positive schizotypy symptoms than negative symptoms (also measured using the Chapman scales). However, neither the Mohanty (2008), Von Strein (2009), nor Strauss (2008) groups examined the disorganization symptom cluster. Given the specific association between executive dysfunction and disorganization symptoms in schizotypy (Kerns, 2006) and the relationship between executive dysfunction and interpersonal dysfunction in schizophrenia (Bowie et al., 2008; Cohen, Forbes, Mann, & Blanchard, 2005), it may be that disorganization symptoms also play a key role. As noted by Kerns (2006), schizotypy facets are moderately to strongly correlated with one another, and of the three schizotypy facets disorganized symptoms have been researched the least, which makes it possible that previous associations with either positive or negative symptoms might be accounted for by the disorganization symptom dimension.

In addition, there may be methodological limitations in the Mohanty (2008) and Von Strein (2009) studies that are improved upon in the present study. The words stimuli used in the Von Strein (2009) study were simply chosen based on research consensus of valence category, and matched on length and frequency (although basis for frequency determination is not indicated in the article). The word stimuli use in the Mohanty (2008) study were chosen based on valence, arousal (high arousal for pleasant and unpleasant words, and low arousal for neutral words), and frequency norms provided by Bradley and Lang's (1999a) Affective Norms for English Words (ANEW), and for word length. However, the ANEW frequency norms are taken from Kucera and Francis' 1967 norms, and may therefore be outdated when compared to the Hyperspace Analogue to Language (HAL) frequency norms used by Larsen and colleagues

(2006) in their meta-analysis of lexical characteristics of prior studies' e-Stroop stimuli, which are taken from Lund and Burgess (1996). Balota and colleagues (2007) of the English Lexicon Project provides both sets of frequency norms (Kucera & Francis' 1967 norms and Lund & Burgess' 1996 HAL norms), but "strongly encourage" users to use the HAL norms, since it has been repeatedly demonstrated that the Kucera and Francis norms are relatively poor estimates of raw frequency (Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004; Zevin & Seidenberg, 2002). Moreover, the Mohanty group (2005, 2008) studies fail to control for orthographic neighborhood, which could also influence e-Stroop reaction times. Finally, arousal level is intentionally different between the emotional and neutral words used by the Mohanty group's (2005, 2008) studies, and may confound the relationship between valence and e-Stroop effect. The present study seeks to address these additional concerns through use of a new e-Stroop stimuli set developed for use herein, and a self-report measure of schizotypy that examines positive, negative, and disorganized symptom clusters.

Purpose

The purpose of this study was to examine affective dysfunction in schizotypy by (1) measuring affective interference on an e-Stroop task carefully designed to tease apart the effects of emotional word valence from other confounding factors such as frequency, orthographic neighborhood, length, and arousal; and (2) comparing these results to those obtained through self-report of trait affectivity. Understanding the pattern of affective bias in schizotypy (and, by extension, possibly schizophrenia) has potentially important clinical implications for developing possible therapeutic interventions, e.g., cognitive remediation programs, that address this intrusive bias toward unpleasant affect. For example, as suggested by Smith and colleagues (2006) with regard to treatment of depression, interventions designed to decrease the relative accessibility of unpleasant affect, such as positive subliminal priming procedures, may attenuate the self-maintaining nature of unpleasant attentional bias.

Hypotheses

Based on levels of trait pleasant and unpleasant affectivity reported by schizophrenia and schizotypy participants in prior studies, it was expected that schizotypal participants would report higher trait affectivity and lower pleasant affectivity than controls. Within the schizotypy group, it was expected that disorganized and positive symptoms would demonstrate stronger correlations with this pattern of increased unpleasant affectivity and decreased pleasant affectivity.

Positive (but not negative) schizotypal symptoms have been shown to correlate with increased interference for unpleasant (but not pleasant) emotion words (Mohanty, et al., 2008). However, executive control, as measured by prepotent inhibition, is associated with disorganization in schizotypy (Kerns, 2006), a symptom dimension that was not examined by Mohanty and colleagues (2008). In addition, disorganization symptoms are associated with increased self-reported emotionality (Kerns, 2006). Thus, it was expected that schizotypal participants would demonstrate increased levels of unpleasant affective bias compared to controls, and that positive and disorganized schizotypy symptoms would show affective bias on the e-Stroop for unpleasant words.

Therefore, the pattern of anticipated results was as follows:

1. Schizotypal participants were expected to (a) show higher amounts of affective interference from unpleasant words on the e-Stroop task as compared to controls, but not from pleasant words; and (b) self-report higher unpleasant and lower pleasant trait affectivity than controls.
2. Within the schizotypy group, disorganized and positive symptoms were expected to show higher correlations than negative symptoms with e-Stroop interference for

unpleasant words, and higher correlations with unpleasant and pleasant trait affectivity scores (which were expected to positively and negatively correlate with positive and disorganized schizotypy, respectively).

3. Among schizotypy participants, it was expected that individuals with higher unpleasant and lower pleasant trait affectivity would be more likely to show stronger affective interference effects for unpleasant words on the e-Stroop task, such that unpleasant e-Stroop interference scores were anticipated to positively correlate with self-reported unpleasant affectivity and negatively correlate with self-reported pleasant affectivity.

Method

Participants

Participants were 49 male and 67 female students recruited from the undergraduate population of Louisiana State University. The sample comprised 96 Caucasians, 14 African-Americans, 2 Asian-Americans, 2 Hispanic-American, and 2 participants self-identified as “other.” The average age was 19.34 (SD=3.74), and all participants were fluent in English. The sample included 81 psychometrically-identified schizotypal students (33 male, 48 female) and 35 non-schizotypal control participants (16 male, 19 female). Students’ eligibility for participation was determined by scores on the Schizotypal Personality Questionnaire-Brief (SPQ-B, discussed in greater detail below), which were obtained from internet-based screening of a larger subject pool of freshmen and sophomore students.

In order to gather these questionnaire responses, an email invitation to participate in an online survey containing the SPQ-B (among other items) was sent to 8591 freshmen and sophomore students, to which 1504 student responded, resulting in 1305 usable questionnaire responses. Individuals either not completing the survey instruments, or endorsing more than two items on the Chapman Infrequency Scale (1983) inconsistency items were excluded. (The Chapman Infrequency Scale inconsistency items are included as Appendix A.) Separate z-scores for the positive, disorganization, and negative (using only items from the “constricted affect” and “no close friends”) domains were computed separately for gender and ethnicity. Individuals were required to have a z-score of 1.6 or above on any of these three domains in order to be invited to participate in the laboratory phase as a member of the schizotypy group. Additionally, individuals with only negative schizotypy z-scores exceeding 1.6 were also required to have a depression score of 0, as measured by the Brief Symptom Inventory (Derogatis & Melisaratos,

1983; Derogatis, 1993), a widely-used and well-validated measure of a wide spectrum of psychological symptoms. (A copy of the BSI depression items is included as Appendix B.) This additional criterion was added in order to exclude participants for whom negative symptoms would likely be confounded by depression symptoms. Control participants were chosen based on z-scores below the mean on all three schizotypy domains and BSI depression ratings.

College graduates do have a lower lifetime prevalence of schizophrenia than the general population, which is consistent with Meehl's (2001) above-cited model of schizophrenia development, given the above-outlined cognitive and functional deficits in schizotypy and schizophrenia and the environmental stressors of lower socioeconomic status. Thus, college students with symptoms of schizotypy might benefit from certain protective factors not present at the same levels in a non-college schizotypy sample. Notwithstanding this limitation, college students have been considered an appropriate sample for the examination of schizotypy, as longitudinal studies have reported that psychometrically identified schizotypal college students are at heightened risk for development of psychotic and schizophrenia-spectrum disorders (Brown et al., 2008; Chapman, et al., 1994; Kwapil, 1998). However, due to lower rates of schizophrenia among college graduates, the results obtained herein might be considered conservative when used to extrapolate to a schizophrenic or larger non-college schizotypy population.

This study was approved by the appropriate Institutional Review Board and all participants provided written informed consent prior to beginning the study.

Measures

Schizotypal Personality Questionnaire-Brief. The Schizotypal Personality Questionnaire-Brief (SPQ-B) (Raine & Behishay, 1995) was used to psychometrically identify

schizotypal individuals. The SPQ-B is a 22-item instrument based on the original 74-item Schizotypal Personality Questionnaire (SPQ, Raine, 1991), and is particularly useful in screening large numbers of individuals. Items on the original SPQ and SPQ-B are answered “yes” or “no,” with each “yes” answer scored one point. To address concerns that this response format is insensitive to degree of symptom severity (Peltier, 1990; Wuthrich, 2005), a five-point Likert scale employed in recent SPQ research was used, with response options ranging from “Strongly Disagree” to “Neutral” to “Strongly Agree,” which has high convergence and improved internal reliability ($\alpha = .95$) compared to the original version (Wurthrich, 2005). A copy of the SPQ-B items is included as Appendix C.

The SPQ-B yields a total score, together with scores for each of the three main sub-factors—cognitive-perceptual, interpersonal, and disorganized—which correspond generally to the positive, negative, and disorganized symptom domains, respectively. Higher scores reflect more severe symptoms. Sample items include: “Have you ever had the sense that some person or force is around you, even though you cannot see anyone?” (cognitive-perceptual scale), “People sometimes find me aloof and distant.” (interpersonal scale), and “Some people think that I am a very bizarre person.” (disorganized scale). Two month test-retest reliabilities range from .86 to .95 (mean = .90). Criterion validity as indicated by correlations between SPQ-B subscales and clinical interview measures of Schizotypal Personality Disorder are good for the total scale (.66), the cognitive-perceptual subscale (.73), and the interpersonal subscale (.63), but are lower for the disorganized subscale (.36) (Raine & Behinsnay, 1995).

Emotional Stroop Task. An e-Stroop task was constructed for this study using words selected from Bradley and Lang’s (1999b) Affective Norms for English Words (ANEW). The ANEW data set was developed and distributed by the NIMH Center for Emotion and

Attention at the University of Florida. It provides a normative set of arousal, valence, and dominance ratings for 1035 words, and was developed as a companion to the existing International Affective Picture System (IAPS, Lang, Bradley, & Cuthbert, 1999) and International Affective Digitized Sounds (IADS; Bradley & Lang, 1999), which are collections of picture and sound stimuli, respectively, that also include these affective ratings. Word valence ratings range from 1-9, and were normed using a bipolar Self-Assessment Manikin (SAM) (i.e., ranging from unpleasant to pleasant on a single spectrum), and word arousal ratings range from 1-9 using a similar SAM model (ranging from calm to highly arousing).

For presentation of this e-Stroop task to participants, word items were grouped into five categories: “unpleasant valence” consisted of words with a valence rating below 4, “neutral valence” consisted of words with a value between 4 and 6, and “pleasant valence” consisted of words with a value above 6. “Low arousal” consisted of words with an ANEW arousal value below 4.07, “neutral arousal” consisted of words with a value between 4.02 and 6, and “high arousal” consisted of words with a value above 6. The first four categories (the “emotional word” categories) consisted of: high arousal/unpleasant valence words, high arousal/pleasant valence words, low arousal/unpleasant valence words, and low arousal/pleasant valence words. Each category contained 20 words. The last category comprised 80 control words neutral in both arousal and valence per ANEW ratings, which were matched to each emotional word on measures of length and syllables, as well as orthographic neighborhood, HAL frequency, and log-transformed HAL frequency, as provided by the English Lexicon Project, a searchable on-line database of these characteristics for over 40,000 words (Balota et al., 2007).

During the testing session, participants were seated in front of a computer monitor. Prior to the beginning of the e-Stroop task, participants were presented with the following printed instructions on the monitor:

In this task you will be shown a series of words. Each will flash on the screen, one after the other.

Your goal is to determine the color that each word is typed in, and press the matching color key on the keypad in front of you as quickly as possible, while trying to be as accurate as possible. In making this decision, you should ignore the content or meaning of the typed word, and focus only on determining its color.

The task began with a practice set of 10 neutral words. After each practice word, feedback regarding the response was presented on the screen (“correct,” “incorrect,” or “no response given”). The practice session was followed by presentation of test items in eight separate blocks: one block of high arousal/unpleasant valence words, one block of high arousal/pleasant valence words, one block of low arousal/unpleasant valence words, one block of low arousal/pleasant valence words, and four blocks of neutral words. Items in each neutral block were grouped to mirror the grouping of their corresponding emotional word counterparts, such that each emotional word set had its own neutral word set matched on lexical characteristics of frequency, orthographic neighborhood, length, and syllables. Order of block presentation was randomized, as was order of item presentation within each block. Participants indicated the ink color in which the stimulus items were printed (yellow, blue, red, or green) by pressing a corresponding color key on the computer keyboard (replacing the “s,” “f,” “h,” and “k” keys, respectively). Items were individually presented on a grey screen (to allow for maximum color contrast) in capital letters for a maximum of 5 seconds, but were removed from the screen once a response selection was made. Within each block, items were separated by a 1 second interval,

during which the computer monitor remained blank. Each block was separated by a 15 second interval, during which the instruction “Please clear your mind and prepare for the next set of words,” was displayed on the computer monitor.

Words were presented to participants in the blocked manner described above (e.g., high arousal/unpleasant, high arousal/pleasant, low arousal/unpleasant, low arousal/pleasant, and neutral) in order to correspond to IAPS categories used for a different purpose in the same data collection procedure. However, the purpose of this study—to isolate the effects of word valence on executory inhibition functioning while controlling for arousal effects—was somewhat different, so slight modification of word set composition was made for purposes of calculating affective interference difference scores. Collapsing the original word groups across high and low arousal levels resulted in unpleasant and pleasant word groupings that revealed significant differences from their neutral control counterparts on other confounding lexical word characteristics. Therefore, in the present analysis, in order to separately analyze unilateral valence effects while controlling for word arousal level, word items have been re-grouped, with some words omitted from the original data set in order to maintain as much similarity as possible among non-valence lexical word characteristics, such that there were no significant differences among the categories along dimensions of length, frequency, arousal, etc. The resulting word groups comprised one group of pleasantly valenced words and one group of unpleasantly valenced words, and one group of neutral words. Because very few words in the neutral valence category received high arousal ratings (Bradley & Lang, 1999a), the neutral category contains words neutral in both valence and arousal. Average arousal levels in the emotional word categories were matched to the neutral arousal level of the neutral word category by selection of high and low arousal words for the emotional word categories. Each analysis group consists of

32 words chosen from the original data set. All three groups were carefully matched such that there were no significant mean differences between any groups on arousal, word length, syllables, HAL frequency, HAL-log frequency, or orthographic neighborhood. A list of the word stimuli used in each category (pleasant, unpleasant, and neutral) is included as Appendix D. This list includes affective and lexical characteristics of each word, as compiled from the ANEW and ELP databases, and mean scores and standard deviations for each characteristic within each word group.

Measurement of affective interference on the e-Stroop task was operationalized in the form of difference scores, calculated as the mean reaction time for correct responses within the neutral word set subtracted from mean reaction time for correct responses within each emotional word set. This method has been utilized by prior studies as an indication of affective interference for emotional word sets, beyond baseline response mechanism reaction time represented by the neutral control set (e.g., Mohanty, et al., 2008). Use of a difference score with comparison to a baseline reaction time to name ink color of neutral words, as opposed to use of simple mean reaction times for just emotional word sets, provides a control of baseline reaction time differences due to more generalized cognitive deficits that might be present among the schizotypal population, thereby identifying increases in reaction time specific to effects of affective interference.

In addition, in order to best determine and control for the influence of potential outlier reaction times caused by momentary lapses in attention by participants, difference scores were also calculated using the median reaction time for each word set, and results using median reaction time differences were compared to those obtained using mean reaction times. Finally, as use of difference scores in e-Stroop analyses has been shown to reduce the reliability of the

measure (Strauss, 2005), difference score analyses were supplemented by multiple regression analyses using the neutral word set reaction times as the initial predictor variable, followed by entry of the relevant emotional word reaction times.

Pleasant and Unpleasant Emotion Subscales. Trait pleasant and unpleasant affectivity was measured using the “Positive Emotion” and “Negative Emotion” subscales, respectively, of the Positive and Negative Affect Schedule (PANAS-X) (Watson & Clark, 1999; Watson, Clark, & Tellegen, 1988). The PANAS-X is a factor-analytically derived measure (Humrichouse, et al., 2007), which presents participants with 60 affectively valenced words (e.g., interested, excited, distressed, and upset), and asks participants to rate to what extent they generally feel this way on a scale from 1 (“very slightly or not at all”) to 5 (“extremely”). The PANAS scales have shown acceptable test-retest reliability for 2-month and 7-year intervals and high convergence with other personality instruments (Bagozzi, 1993; Watson & Clark, 1999), and have demonstrated sufficient internal reliability, with coefficient alphas ranging from .76 to .83 (Watson & Clark, 1997; Humrichouse, et al., 2007). A copy of the PANAS-X is included as Appendix E.

Procedure

Participants were seated in front of a computer monitor, with laboratory assistants out of view. The experiment was run using Eprime software version 2.0 (Psychology Software Tools, Pittsburgh, PA). The measures analyzed herein were administered to participants as part of a larger data collection effort, which required approximately two hours of testing, and consisted of a session in which a free speech sample and speech samples responsive to IAPS photos presented on a computer monitor were recorded and various questionnaires were answered on a computer monitor, in addition to the PANAS and e-Stroop segments.

Analyses

All proposed analyses were run using SPSS analytical software, version 16.0 (2007).

Demographic Variables

Scores obtained on the SPQ-B, PANAS-X, and e-Stroop were analyzed across various demographic variables, e.g., gender, age, and SES to determine the presence of any potentially confounding variables. Demographic variables found to statistically differentiate performance on these measures were entered as control variables in the below analyses.

Emotional Stroop Construction

In order to check the method by which average arousal level was used to control for arousal effects between emotional and control word sets, polynomial contrast trend analyses were performed using segmented word reaction time averages based on arousal level distribution. To perform this polynomial trend analysis, word arousal level was segmented into nine arousal level distribution groups, based on ANEW Likert value scale (e.g., word arousal Likert value 0 through 1 was transformed to a segment value of 1, Likert values 1.01 through 2 were transformed to a segment value of 2, etc.). Values of this arousal level distribution variable ranged from 3 – 9.

The purpose of these analyses was to confirm that the relationship between word arousal level and reaction time was linear, which would support use of words with arousal values in the 4-6 range (per the ANEW Likert scale) in the e-Stroop neutral baseline word set to control for word arousal values above and below this range in the emotional word sets; and to rule out a cubic relationship (e.g., one where lower and higher arousal levels increased reaction time over

that for words of neutral arousal level) which would indicate that the averaging method used to control for arousal level across word groups likely failed to accomplish this goal.

Schizotypy v. Controls

The schizotypy and control groups were compared on e-Stroop performance using a mixed model repeated-measures one-tailed 2 x 2 ANCOVA, with group membership (schizotypy v. control) as the between-subject variable, affective word condition (pleasant v. unpleasant) as the within-subject variable, e-Stroop reaction time mean difference scores as the dependent variable, and gender as a covariate. These two groups were also compared on their self-reported pleasant and unpleasant affect using a mixed model repeated-measures one-tailed 2 x 2 ANCOVA, with group membership (schizotypy v. control) as the between-subject variable, affective trait type (pleasant v. unpleasant) as the within-subject variable, PANAS-X subscale score as the dependent variable, and GPA as a covariate. Alpha levels for these ANCOVA analyses were set at .025, using the Bonferroni correction for multiple analyses.

Hierarchical regression analyses were also performed with total SPQ-B scores as the dependent variable, and the neutral word set mean scores entered as the initial predictor variables, followed by mean emotional word category scores (with each emotional word category used in a separate analysis). Variability in total SPQ-B score explained by neutral word set reaction time indicates effects of schizotypy severity on task response time due to differences in response patterns not related to emotional interference, such as generalized cognitive deficits, and thus provided a measure of control for these sources of variability once the relevant emotional word set reaction times were added to the prediction model. The purpose of these analyses was to determine whether the emotional component of either emotional word set

explains any additional variability in the prediction of the overall severity of schizotypy symptoms, beyond variability explained by the neutral word set.

Within Schizotypy, Across Symptom Dimensions

In recognition of the heterogeneous nature of schizotypy symptom cluster presentation, the relationship of the separate symptom dimensions (positive, negative, and disorganized) to e-Stroop and PANAS-X scores was examined. Given the purported taxonic structure of schizotypy (e.g., Blanchard et al., 2000; Horan et al., 2004; Lezenwegger, 1999) it is appropriate to examine the relationship between different schizotypy symptom sub-scale scores and measures of affective dysfunction within only the schizotypy group. This approach is supported by the findings of Mohanty and colleagues (2008), who examined the relationship between schizotypy scores within a non-schizotypal specific sample of college students. These researchers found a non-linear relationship between positive schizotypy scores and e-Stroop interference, with significant effects demonstrated only in the highest quartile of schizotypy scores, which is consistent with the proposition that these effects occur only within a sub-group of taxometrically distinct schizotypy participants. This approach was further justified in the present analysis, as the total participant group does not represent a continuous sample with regard to schizotypy symptom dimension scores, due to the selection of schizotypy and control groups that significantly differed on SPQ-B scores.

The relationship between affective interference and schizotypy symptom dimensions (i.e., positive, negative, and disorganized) was assessed by one-tailed correlations between the SPQ subscale scores and pleasant and unpleasant e-Stroop interference difference scores. To supplement this analysis, using mean category reaction times instead of reaction times of difference scores, hierarchical regression analyses were also performed to determine

whether the reaction time in emotional word conditions explained any additional variability above reaction time in the neutral condition in the prediction of severity of each schizotypy symptom dimension. Dependent variables were SPQ-B positive, negative, and disorganization symptom subscale scores. The independent variable for Step 1 in each regression analysis was the mean reaction time for the neutral word condition, with mother's education level also added as a confounding variable for Step 1 in models predicting severity of positive SPQ-B scores. Independent variables for Step 2 in each analysis were neutral word group mean reaction times (plus mother's education level for the model predicting SPQ-B positive scale scores) followed by either pleasant or unpleasant word group mean reaction times.

The relationship between affective interference and self-reported trait affectivity within the schizotypy group was assessed by one-tailed correlations between the pleasant and unpleasant e-Stroop interference scores and pleasant and unpleasant PANAS-X subscale scores. To supplement this analysis hierarchical regression analyses were also performed to determine whether the reaction time in emotional word conditions explained any additional variability above reaction time in the neutral condition in the prediction of trait affectivity. Dependent variables were PANAS-X subscale scores. The independent variable for Step 1 in each regression analysis was the mean reaction time for the neutral word condition. Independent variables for Step 2 in each analysis were neutral word group mean reaction times followed by either pleasant or unpleasant word group mean reaction times.

The relationship between schizotypy symptom dimensions (i.e., positive, negative, and disorganized) and self-reported trait affect was assessed by one-tailed correlations between the SPQ-B subscale scores and pleasant and unpleasant PANAS-X subscale scores.

Power Analysis

Power analyses were conducted for the primary hypothesis using G*Power software 3.0.8 (Buchner, Faul, & Erdfelder, 2007). Power analysis for the ANCOVA performed comparing schizotypy and control groups on e-Stroop performance (ANCOVA: Repeated measures; between factors, within factors, and within-between interaction; $\alpha = .05$, power = .80, groups = 2, repetitions = 2, correlation among repeated measures = .04 (Mohanty, et al. (2008)) indicated a necessary minimum sample size of 68 total participants (68 required to detect differences in between-subject factors, 64 to detect differences in within-subject factors, and 64 to detect an interaction between the two factors), i.e., approximately 34 in each group, to achieve adequate power to detect a small effect size ($d = .25$). Therefore, samples sizes obtained in this study were sufficient to reveal a small effect size for the 2 x 2 ANCOVA comparing the schizotypy and control groups across e-Stroop interference scores.

Power analysis for the ACNOVA performed comparing schizotypy and control groups on PANAS-X self-reported affectivity scores (ANCOVA: Repeated measures; between factors, within factors, and within-between interaction; $\alpha = .05$, power = .80, groups = 2, repetitions = 2, correlation among repeated measures = -.25 (Crawford, & Henry (2004)) indicated a necessary minimum sample size of 82 total participants (50 required to detect differences in between-subject factors, 80 to detect differences in within-subject factors, and 82 to detect an interaction between the two factors), i.e., approximately 41 in each group, to achieve adequate power to detect a small effect size ($d = .25$), and a necessary minimum sample size of 22 total participants (16 required to detect differences in between-subject factors, 22 to detect differences in within-subject factors and an interaction between the two factors), i.e., approximately 11 in each group, to detect a medium effect size ($d = .5$). Therefore, sample sizes

obtained in this study were sufficient to reveal an effect size just over the small effect size threshold for the 2 x 2 ANCOVA comparing the schizotypy and control groups across PANAS-X subscale scores.

Power analysis for all correlations performed with the schizotypy group (Correlation: one-tailed, $r = .3$, $\alpha = .05$, power = .80) indicated a necessary minimum sample size of 64 participants to achieve adequate power to detect a medium effect size ($r^2 = .09$). Therefore, sample sizes obtained in this study were sufficient to reveal a medium effect size for these correlations. The sample sizes in this study thus exceeded requirements for the large effect size found by Mohanty (2008) for the correlation between positive schizotypy and unpleasant emotional interference; and were sufficient to detect the medium effect sizes found by Lewandowski (2006) for correlations between positive schizotypy symptoms and unpleasant affect.

Results

Exploration of the Variables

Normality of Variable Distributions. Kolmogorov-Smirnov tests of normality confirmed that all dependent variables met normality assumptions except for the following: Within the schizotypy group, the distribution of both SPQ disorganized ($D(81) = .20, p < .01$) and negative ($D(81) = .16, p < .01$) scale scores deviate significantly from a normal distribution, and the PANAS-X unpleasant affect subscale score distribution was significantly different from a normal distribution ($D(81) = .11, p < .03$). In addition, within the total participant group the following demographic variables differed from normality: age ($D(108) = .36, p < .001$), GPA ($D(108) = .10, p < .01$), mother's education level ($D(108) = .26, p < .001$), and father's education level ($D(108) = .25, p < .001$). Therefore non-parametric tests (Mann-Whitney, Spearman's, and Krushall-Wallis) were utilized for analyses involving these variables.

Use of Mean v. Median Difference Scores in the Emotional Stroop Analysis.

In order to test whether use of median difference scores would better control for effects of potential outlier data, the below-detailed series of tests were also run using median difference scores. However, use of median difference scores proved to be either as sensitive as or less sensitive than use of mean difference scores. Therefore only the results of analyses using mean difference scores are reported below for purposes of consistency and clarity.

Emotional Stroop Construction. There was a trend-level linear trend for word response reaction time to increase as arousal level increased within both the entire participant population and the schizotypy group ($F's > 32.29, p's > .09$). Within the control group there was a trend-level sixth order trend ($F(6, 147) = 18.03; p = .06$), which appears simply to indicate a

lack of coherent relationship between arousal and reaction time in the control group, as there was a range of only seven arousal levels in the stimuli sample. Thus, overall, as arousal level increases, reaction time increases; and this relationship appears driven by a positive linear relationship between reaction time and arousal level within the schizotypy group. Therefore, the method by which average arousal level was used to control for both high and low word arousal values in the emotional word categories appears methodically justifiable.

Demographic Variables. Scores obtained on the SPQ-B subscales (within the schizotypy group), PANAS-X, and e-Stroop were analyzed across the following demographic variables to determine the presence of any confounding variables: gender, age, ethnicity, GPA, and socio-economic status (using participant's father's and mother's education level as a proxy measure of SES, although it is plausible that a relationship of any demographic variables with these measure could also represent the influence of heritable intelligence levels).

Within the total participant group men demonstrated significantly less mean affective interference than women for unpleasant words, as evidenced by lower difference scores for unpleasant word mean reaction time for men (Mdn = -4.90, M = -4.94, SD = 58.31) as compared to women (Mdn = 18.73, M = 19.67, SD = 61.64), $U = 1205$, $p < .05$; and GPA was significantly positively correlated with PANAS-X pleasant affect scores ($r = .20$, $p < .05$). Within the schizotypy group mother's education level was positively correlated with SPQ-B positive symptom scores ($r = .24$, $p > .05$). Thus, these variables will be entered in the below analyses as control variables where relevant. There were no other significant associations between demographic and dependent variables.

Schizotypy v. Controls

Table 1 presents the mean word group reaction time and reaction time difference scores for the schizotypy and control groups. See Table 1. The ANCOVA examining e-Stroop reaction times across the schizotypy and control groups revealed no significant main effects or interactions (F values all $< .77$, p values all $> .19$). See Figure 1. Consistent with these results, no significant results were found for supplemental hierarchical regression analyses performed to determine if emotional word reaction time scores added significant predictive value above that of neutral words in predicting severity of total schizotypy symptom scores within entire group (all model F 's $< .19$, p 's $> .83$; ΔR^2 's for Step 2 $< .01$, p 's $> .54$; β 's $< .12$, p 's $> .54$).

Table 1

Mean Reaction Times (and Standard Deviation) by Group (in ms.)

	Word valence conditions			Difference scores	
	Pleasant	Unpleasant	Neutral	Pleasant	Unpleasant
Controls	679.70 (143.86)	687.20 (122.36)	674.85 (134.13)	4.85 (48.54)	12.35 (68.84)
Schizotypy	686.74 (94.40)	688.54 (95.51)	680.34 (88.81)	6.40 (59.25)	8.20 (57.93)

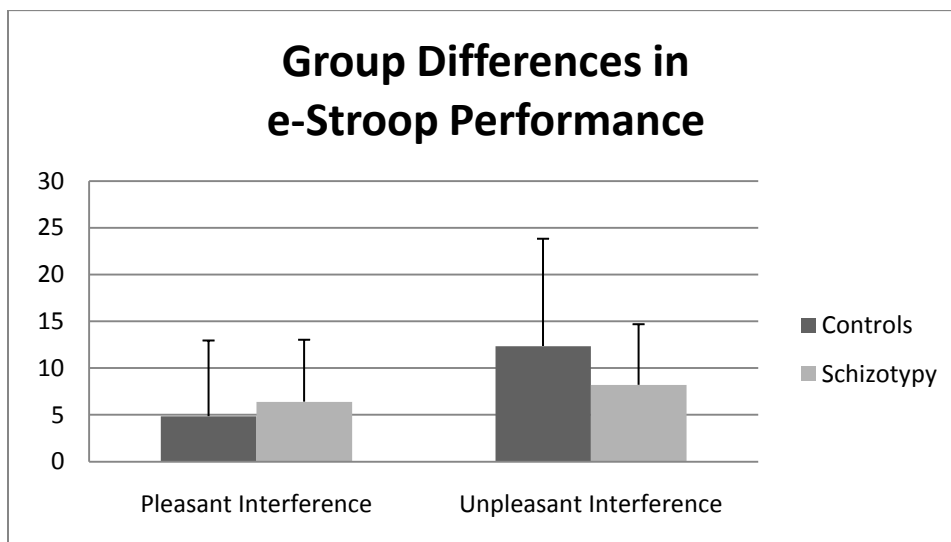


Figure 1: Group Differences in e-Stroop Performance

The ANCOVA examining PANAS-X scores across the schizotypy and control groups revealed no significant main effects (F 's < 2.27 , p 's $> .13$). There was, however, a significant interaction between PANAS-X affect type and group membership ($F(1,110) = 37.33$, $p < .001$) with the schizotypy group self-reporting less pleasant trait affect ($M = 31.15$, $SD = 6.26$) compared to controls ($M = 37.69$, $SD = 7.63$), and more unpleasant trait affect ($M = 24.69$, $SD = 7.23$) compared to controls ($M = 17.06$, $SD = 6.46$). See Figure 2.

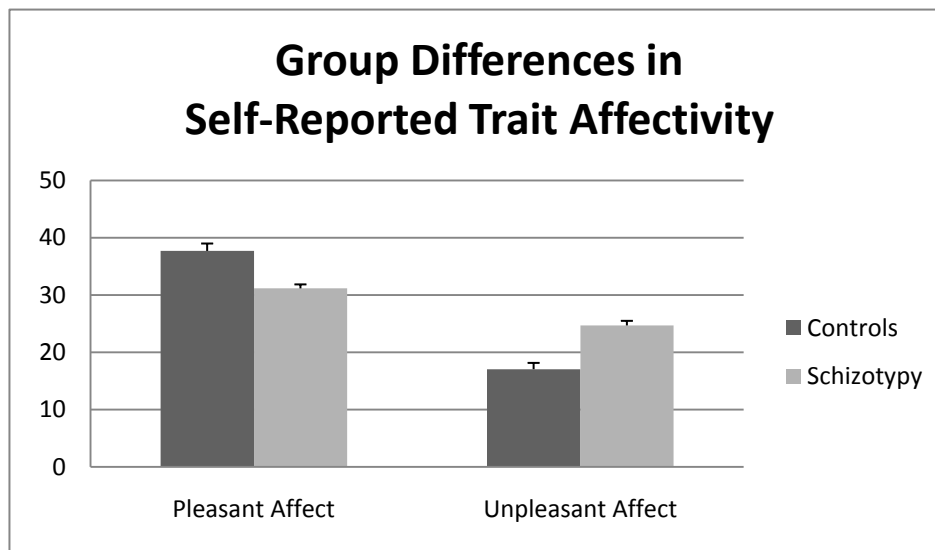


Figure 2: Group Differences in Self-Reported Trait Affectivity

Within Schizotypy, Across Symptom Dimensions

Correlations between e-Stroop performance and schizotypy symptom dimensions revealed only a significant correlation between disorganization symptoms and difference scores for mean reaction time in the unpleasant word condition. See Table 2. This suggests that as the disorganization symptoms of schizotypy increase, so does affective interference due to unpleasant stimuli, reflecting a possible connection between increasing cognitive disorganization and decreasing ability to inhibit unpleasant emotional reactivity.

Table 2

Correlations between SPQ-B subscales and E-Stroop Performance			
	SPQ Positive Subscale	SPQ Negative Subscale	SPQ Disorganization Subscale
Mean Pleasant Word Interference	.09	-.03	-.04
Mean Unpleasant Word Interference	-.03	-.01	.20*

* $p < .05$

Results of hierarchical regression analyses were consistent with correlation analyses—the only regression model that significantly predicted symptom severity was a model using neutral word reaction time and unpleasant word reaction time to predict disorganization symptom scores. See Table 3. (For purposes of brevity and clarity only results of this analysis are reported in tabular format.) No other regression models of emotional word reaction time significantly predicted schizotypy symptom scores (all model F 's < 2.46 , p 's $> .06$; all ΔR^2 's for Step 2 $< .01$, p 's $> .53$; all β 's $< .17$, p 's $> .11$, exclusive of mother's education level as a significant covariate).

Table 3

Regression Model for Neutral and Unpleasant Word Mean Reaction Time As Predictors of Schizotypy Disorganization Symptom Severity

	<i>B</i>	<i>SE B</i>	β
Step 1			
Constant	3.73	1.92	
Mean neutral word RT	-0.01	0.01	-.10
Step 2			
Constant	2.73	1.92	
Mean neutral word RT	-0.01	0.01	-.45*
Mean negative word RT	0.01	0.01	-.44*

Note $R^2 = .01$ for Step 1 ($p > .05$); $\Delta R^2 = .07$ for Step 2 ($p < .05$). * $p < .05$.

One-tailed correlations between e-Stroop interference scores and PANAS-X subscale scores revealed a trend level correlation between self-reported unpleasant affect and

unpleasant word interference. There were no significant correlations. See Table 4. Hierarchical regression analyses were consistent with these results—neither mean pleasant nor unpleasant word reaction time scores added significant predictive value above that provided by mean reaction time for neutral words in predicting pleasant and unpleasant trait affect self-reported on the PANAS-X (all model F 's < 1.73, p 's > .18; all ΔR^2 's for Step 2 < .04, p 's > .11; all β 's < .31, p 's > .11).

Table 4

Correlations between PANAS-X subscales and E-Stroop Performance

	PANAS Pleasant Affect	PANAS Unpleasant Affect
Mean pleasant word interference	.09	-.05
Mean unpleasant word interference	.03	.17[†]

[†] $p < .10$

Correlations between schizotypy symptom dimensions and PANAS-X self-reported trait affect scores revealed a significant inverse correlation between negative schizotypy symptoms and self-reported pleasant trait affect, and a significant correlation between positive schizotypy symptoms and self-reported unpleasant trait affect. See Table 5. There was also a trend-level inverse correlation between positive schizotypy symptoms and self-reported pleasant affect. When positive schizotypy scores were separately analyzed using a hierarchical regression model to control for mother's education level, however, only unpleasant trait affect added significant unique contribution to the variance in SPQ positive scale scores. The change in variance attributable to pleasant affect was nonsignificant. See Tables 6 and 7.

Table 5

Correlations between SPQ-B and PANAS-X Subscales

	SPQ Positive Subscale	SPQ Negative Subscale	SPQ Disorganization Subscale
PANAS Pleasant Affect	-.15	-.28**	.06
PANAS Unpleasant Affect	.21*	.01	.06

*p < .05

**p < .01

Table 6Regression Model for Mother's Education Level and PANAS-X Unpleasant Affect
As Predictors of Schizotypy Positive Symptom Severity

	<i>B</i>	<i>SE B</i>	β
Step 1			
Constant	-3.12	1.58	
Mother's education level	0.27	0.10	.28*
Step 2			
Constant	-4.79	1.68	
Mother's education level	0.29	0.10	.30**
PANAS Unpleasant Affect	0.06	0.02	.26*

Note $R^2 = .08$ for Step 1 ($p < .05$); $\Delta R^2 = .07$ for Step 2 ($p < .05$). * $p < .05$, ** $p < .01$.**Table 7**Regression Model for Mother's Education Level and PANAS-X Pleasant Affect
As Predictors of Schizotypy Positive Symptom Severity

	<i>B</i>	<i>SE B</i>	<i>B</i>
Step 1			
Constant	-3.12	1.58	
Mother's education level	0.27	0.10	.28*
Step 2			
Constant	-2.16	1.71	
Mother's education level	0.29	0.10	.30**
PANAS Pleasant Affect	-0.04	0.03	-.15

Note $R^2 = .08$ for Step 1 ($p < .05$); $\Delta R^2 = .07$ for Step 2 ($p < .05$). * $p < .05$, ** $p < .01$.**Post-Hoc Analyses**

No *ex ante* hypotheses were formed about possible differences in error rates or potential patterns of emotional “facilitation” effects (i.e., whereby participants demonstrate

decreased reaction time for emotional words compared to controls, discussed in further detail below). Both areas were explored in a post-hoc fashion to determine whether the data revealed any unexpected performance differences between the two groups or across schizotypy symptom dimensions.

Error Analysis. All above e-Stroop analyses were performed using correct-response trials only—incorrect responses were excluded. Given the more generalized cognitive deficits demonstrated in schizophrenia and schizotypy, and more specifically those demonstrated in executive control, total error rates and proportional increases in error rates for emotional words were analyzed to determine if any differences in affective reactivity could be observed as increased error rates for emotionally-salient words. Distributions of these error rates differed significantly from the normal distribution (D 's > .17, p 's < .001), thus non-parametric tests were used.

The schizotypy group demonstrated more relative errors in the unpleasant emotional word condition than controls. Because many participants did not make any errors during neutral word presentations, and thus a neutral word category error baseline could not be calculated, the impact of affective interference on error rates was operationalized as the percentage decrease in correct responses in the emotional word conditions, compared to the neutral word condition. A Mann-Whitney test found a trend-level difference between groups on percentage decrease of correct responses for unpleasant words ($U(116) = 1147.00$, $p < .10$), with the schizotypy group demonstrating a slightly larger relative decrease in correct responses in the unpleasant word category (Mdn = 0.00, $M = 0.01$, $SD = .04$) than controls (Mdn = 0.00, $M = .01$, $SD = .03$). There were no significant differences for the pleasant word group ($U(116) =$

1416.50, $p = .99$), or significant correlations between percentage decrease in correct responses for emotional words and schizotypy symptom dimensions (r 's $< .03$, p 's $> .40$).

A Mann-Whitney test comparing schizotypy participants and controls on total error rate found no significant differences ($U(116) = 1378.50$, $p = .81$). Within the schizotypy group, though, total errors were significantly correlated with the disorganization dimension ($r = .37$, $p = .001$) and total SPQ-B scores ($r = .25$, $p < .05$). Total error rates, however, could reflect differences in emotional reactivity, or simply more generalized executive attention deficits.

In addition, the following demographic variables were found to correlate with error rates: Age was found to inversely correlate with total errors, at trend level ($r = -.16$, $p < .10$); and percentage decrease in correct responses in the unpleasant word condition was significantly correlated with mother's education level ($r = .20$, $p < .05$). Finally, percentage decrease in correct responses in the pleasant and unpleasant word categories were significantly correlated with each other in both the schizotypy ($r = .44$, $p < .001$) and total ($r = .46$, $p < .001$) participant groups, indicating that participants' relative error rates tended to be partially consistent across emotional content.

Facilitation Effects. In addition, it was speculated that a lack of differences found in emotional reactivity between the two groups could be due to certain subgroups of the participant pool demonstrating "facilitation" effects, i.e., when the reaction time to name ink color for emotional words is shorter than reaction time required to name the ink color of emotionally neutral words (Andersson, et al., 2005; Andersson, Westoo, Johansson, & Carlbring, 2006; Avero, Corace, Endler, and Calvo, 2003; Koven, Heller, Banich, & Miller). While both interference and facilitation effects are theorized to reflect attentional bias toward emotionally

salient words, interference is theorized to occur at earlier stages in processing, and facilitation is theorized to occur at later stages as an attempt avoid emotionally salient words by indicating ink color choice as quickly as possible to make the current word disappear from the screen (Andersson et al., 2006).

A series of two-tailed one-sample t-tests were performed to determine the extent to which any difference scores were significantly different from a test value of 0, which represents no increased reactivity in the emotional word condition. No significant facilitation effects (e.g., difference scores significantly lower than 0) were found across the total group, schizotypy group, controls, men, or women. Unpleasant words demonstrated significant interference effects (i.e., difference scores significantly higher than 0) only within the female participant group, and a trend interference effect within the total group. No other interference effects were significant. See Table 8. Thus, there were no facilitation effects apparent in this study; and statistically significant absolute, rather than relative, interference effects were driven by female participants.

Table 8

Magnitude of Affective Interference (in ms.)

Group	Pleasant word condition		Unpleasant word condition	
	Mean RT difference score (SD)	<i>t</i> statistic	Mean RT difference score (SD)	<i>t</i> statistic
Total	5.92 (55.94)	1.14	9.49 (61.25)	1.67 [†]
Schizotypy	6.40 (59.25)	0.97	8.20 (57.93)	1.27
Control	4.85 (48.55)	0.60	12.35 (68.84)	1.08
Men	-1.43 (48.00)	-0.21	-4.94 (58.31)	-0.59
Women	11.10 (60.74)	1.51	19.67 (61.64)	2.63*

* $p < .05$

[†] $p < .10$

Discussion

This study examined the relationships among implicit emotional reactivity, explicit trait affectivity, and schizotypy symptoms. The schizotypy group replicated the pattern of self-reported trait affective dysfunction found in prior studies—schizotypal participants reported experiencing more unpleasant affect and less pleasant affect than controls, unpleasant affect was correlated with positive symptoms, and pleasant affect was inversely correlated with negative symptoms. However, no differences were found between the schizotypy and control groups on e-Stroop performance. Within the schizotypy group, disorganization symptoms were found to significantly correlate with affective interference for unpleasant words, but there were no correlations between e-Stroop performance and self-reported trait affect. This section explores the implications of these results and their place among current theories of affective dysfunction in schizotypy, as well as possible directions for further research.

Contrary to expectations, schizotypy and control groups did not differ on e-Stroop performance. Because unpleasant interference effects were shown to be related only to disorganization symptoms, it appears likely that the relationship between schizotypy and emotional interference effects is masked within the larger heterogeneous schizotypy group when comparisons are made to controls at the group level. As hypothesized, though, patterns of self-reported trait affect in schizotypy were consistent with prior research. Schizotypal participants reported less positive and more unpleasant trait affect than those in the control group. Thus, patterns of implicit affective interference did not replicate patterns of explicit affective dysfunction. One possible explanation for this result is that the implicit affective interference measurement task of the e-Stroop lacks the discriminating power of an explicit self-report measure (MacDonald & Carter, 2002)—in other words, similar patterns of differences in

affectivity between the schizotypy group and controls reflected in PANAS-X responses could be present at a more implicit level, but while the PANAS-X is a sensitive enough measure to capture those gross differences assessed by explicit self-report, the e-Stroop may have insufficient discriminating power to capture more discrete significant differences at the margin between neutral and emotional word category reaction times on the order of magnitude of milliseconds.

The hypothesis that within the schizotypy group disorganized and positive symptoms would correlate with e-Stroop interference for unpleasant words was partially supported. Disorganization, but not positive, symptoms demonstrated a significant correlation with unpleasant affective interference. These results are inconsistent with prior results of Mohanty and colleagues (2008), and Von Strein and Von Kampen (2009), which found correlations between positive schizotypy symptoms and unpleasant affective interference on the e-Stroop. One possible reason for the discrepancy is that these prior studies did not separately measure disorganization symptoms. As noted by Kerns (2006), in studies that do not assess disorganization, results implicating positive schizotypy symptoms may be confounded with disorganization symptoms. In addition, earlier studies did not control for differences in arousal level between emotional and neutral words. This study expands the existing literature by providing a more specific understanding of the relationship between unpleasant emotional reactivity and schizotypy symptom dimensions, including a more precise measure of heterogeneous schizotypy symptom dimensions, and isolating the effects of word valence from arousal level on emotional interference.

These results support the theory that deficits in executive inhibitory control related to disorganization symptoms may allow an unpleasant affective bias to contaminate

pleasurable experiences. This unpleasant bias could create a type of negative feedback system whereby abstract representations of pleasant experiences are adulterated by an improperly inhibited unpleasant affective bias, thereby further contributing to a subjective sense of unpleasant trait affect. Such a reciprocal mechanism would be consistent with Meehl's concept of anhedonia and aversive drift in schizotypy, in which "[n]egative affective tone seems over time to become stronger and statistically preponderant over positive" (Meehl, 2001, p. 190). This avenue for interference of unpleasant affective bias could be specific to schizophrenia spectrum disorder, or it might be a more generalizable problem for individuals evidencing cognitive disorganization (e.g., mothers demonstrating disorganized attachment styles responded to negative attachment/emotion stimuli more slowly than to neutral stimuli on an e-Stroop task; Atkinson, et al., 2009). Future research could compare e-Stroop performance in schizophrenia-spectrum disorders directly to performance by participants with other disorders involving cognitive and affective dysfunction to explore the specificity of this effect. Future research could also further examine whether more specific aspects of cognitive dysfunction, particularly regarding executive inhibitory control mechanisms, are related to unpleasant affective interference.

Self-reported trait affectivity demonstrated expected patterns of relationship to schizotypy symptom dimensions. Pleasant trait affect on the PANAS-X was significantly inversely correlated with negative schizotypy symptoms, reflecting a more traditional conceptualization of anhedonia as an absence of or deficit in the experience of pleasant emotion; and unpleasant trait affect on the PANAS-X was significantly correlated with positive schizotypy, reflecting greater emotional reactivity (Kerns, 2006; Meehl, 2001). However, the hypothesis that dysfunctional patterns of trait affectivity in schizotypy would be associated with

stronger affective interference effects for unpleasant words on the e-Stroop task was not supported. One possible explanation for this result is that the implicit affective interference measurement task of the e-Stroop lacks the sensitivity of an explicit self-report measure (MacDonald & Carter, 2002). It might also be that while the explicitly understood subjective experience is appreciated and expressed in more generalized terms of less pleasant and more unpleasant affect than controls, the underlying implicit emotional experience is more specific to a particular domain of unpleasant affective experience. For example, it has been suggested that anhedonia in schizotypy may be specific to unrewarding experiences in the social domain (Kerns, Docherty, & Martin, 2008). Such possibility that implicit affective reactivity may be specifically related to dysfunctional reactivity in social contexts would be consistent with the fact that, in general, prior research using the e-Stroop to examine emotional reactivity to disorder-specific words (e.g., phobia-specific words) has demonstrated more robust reactivity effects overall than reactivity to more generalized pleasant and unpleasant words (Larsen, et al., 2006). Alternatively, it might be that the relationship between negative affective interference and explicitly reported affective dysfunction strengthens as the illness progresses. Many theorists have postulated that unpleasant affect increases over time (e.g., “aversive drift”; Meehl, 2001), so it could be that the correlation between implicit and explicit measures increases as schizophrenia-spectrum symptoms manifest. The data suggest this would be particularly true for disorganized symptoms. Future research on e-Stroop performance could lend support to this idea by examining whether affective interference demonstrates a more direct relationship to trait affect in schizophrenia.

Post-hoc analyses of increased error rates for emotional words revealed a trend-level difference between groups, with the schizotypy group demonstrating a slight relative

increase in errors for the unpleasant word condition, which may represent an alternative measure of emotional reactivity. However, there were no significant correlations between relative increase in error rates in the emotional word conditions and any of the schizotypy symptom dimensions. This could be due to differential discriminating power of the two measures (MacDonald & Carter, 2002)—given the restricted range of percentage decrease in correct responses, it could be that group differences are detectable but more subtle differences based on symptom severity within the prodromal phase of schizotypy are not. Percentage decrease in correct responses in the pleasant and unpleasant word categories were significantly correlated with each other. To this extent, individuals who make more errors are likely to do so for emotional words regardless of valence. However, approximately 75% of the variance in increased errors between the two affective conditions due to other factors remains unexplained. In addition, the schizotypy group as a whole did not differ from controls on total error rates from the control group, but consistent with more generalized executive control deficits (Bowie et al., 2008; Spitznagel & Suhr, 2002) both the disorganization symptom dimension and total SPQ-B scores were significantly correlated with total errors in the schizotypy group, suggesting more impulsive responsive style or an increased rate of non-responses (e.g., momentarily blanking out).

Post hoc analyses failed to find any significant facilitation effects. This set of analyses, however, did reveal additional information about e-Stroop interference effects. When compared to a null standard of no affective interference (i.e., an e-Stroop difference score of 0), only women demonstrated significant absolute interference effects for unpleasant words, which likely drove the trend-level unpleasant interference effects demonstrated within the total participant group.

Influence of gender issues was also apparent in demographic analyses. First, women demonstrated more unpleasant interference on the e-Stroop than men within the total participant group. This suggests that prior research documenting higher amounts of emotional expressivity in women compared to men (Bachorowski & Owren, 1995; Scherer, 2003) may be related to underlying differences in emotional reactivity at a more rudimentary cognitive level, and not just to socialized differences, at least for the experience of unpleasant affect (McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008). Interestingly, though, there were no gender differences in self-reported trait affect. Thus, while women evidenced greater emotional reactivity than men for unpleasant words on the e-Stroop, they did not report subjectively experiencing more unpleasant affect on the PANAS-X. It may be that women must experience a higher amount of implicit unpleasant affective bias than men before they explicitly self-identify as experiencing more global trait-level unpleasant affect. Such differences could be influenced by internalized societal norms expecting higher levels of emotionality in women. In addition, maternal education, but not paternal education, was correlated with positive schizotypy symptoms and a relative increase in errors in the unpleasant word condition (although range in maternal and paternal education is similar). It may be speculated that this result reveals an increased level of symptom exacerbation among schizotypy participants whose mothers obtained higher education, and possibly spent more time working outside of the home. Alternatively, it may be that individuals with higher positive schizotypy symptoms who successfully navigate the educational system to reach the university level are able to do so due to the operation of certain protective factors, one of which may be maternal education level, whether by direct influence on family academic values or mediated by resulting improvement in socioeconomic status.

Certain limitations of the present study complicate interpretation of the results. While psychometrically-identified schizotypal college students have been shown to be at increased risk for later development of schizophrenia spectrum disorders, this relationship is weaker than that in a non-college educated population (Brown et al., 2008; Chapman, et al., 1994; Kwapil, 1998). Generalizability concerns are also raised by the lack of ethnic diversity within the sample. In addition, in this study arousal was balanced by averaging across emotional and neutral word sets, with neutral sets containing words with mid-range arousal values and emotional word sets containing words with arousal values in the high and low range. Although polynomial trend contrast analysis confirmed a linear increase in reaction time over increasing arousal level, thereby supporting the method used to control for arousal, a more precise method of arousal control may improve the psychometric quality of the e-Stroop for isolating valence reactivity effects. Further analysis focusing on the arousal dimension of emotion may also reveal important information about affective dysfunction in schizophrenia-spectrum disorders (Dresler, Meriau, Heekeren, & van der Meer, 2009). Finally, psychometric quality of the e-Stroop task could also be improved by implementation of a verbal as opposed to manual response recording mechanism, a practical limitation of this study (Brown & Besner, 2001; Sharma, & McKenna, 1998).

Limitations notwithstanding, this study does reveal that increasing disorganization symptoms in schizotypy are related to unpleasant affective interference as revealed by e-Stroop performance. Further exploration of the interplay between executive inhibitory control deficits, in-the-moment emotional experience, negative affective trait bias, and the pathway of influence of these factors on affective dysfunction has potentially important clinical implications. For example, as has been suggested with regard to treatment of depression (Smith, et al., 2006),

interventions designed to decrease the relative accessibility of unpleasant affect, such as pleasant subliminal priming procedures, may attenuate the self-maintaining nature of unpleasant attentional bias. Moreover, further exploration of these relationships among facets of affective dysfunction in schizophrenia could provide a basis for comparison to those demonstrated at the prodromal schizotypal level of the disease model. Any changes revealed in e-Stroop performance over evolving stages of disorder progression could suggest pathway models for the influence of different affective factors on affective dysfunction in schizophrenia, and by extension more global functional deficits.

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Appendix A

Chapman Infrequency Scale Items

1. Driving from New York to San Francisco is generally faster than flying between these cities.
2. I cannot remember a time when I talked with someone who wore glasses.
3. I find that I often walk with a limp, which is the result of a skydiving accident.
4. I believe that most light bulbs are powered by electricity.

Appendix B

Brief Symptom Inventory

1	Not at all
2	A little bit
3	Moderately
4	Quite a bit
5	Extremely

1. Nervousness or shakiness inside.
2. Faintness or dizziness.
3. The idea that someone else can control your thoughts.
4. Feeling others are to blame for most of your troubles.
5. Trouble remembering things.
6. Feeling easily annoyed or irritated.
7. Pains in heart or chest.
8. Feeling afraid in open spaces.
9. Thoughts of ending your life.
10. Feeling that most people cannot be trusted.
11. Poor appetite.
12. Suddenly scared for no reason.
13. Temper outbursts that you could not control.
14. Feeling lonely even when you are with people.
15. Feeling blocked in getting things done.
16. Feeling lonely.
17. Feeling blue.
18. Feeling no interest in things.
19. Feeling fearful.
20. Your feelings being easily hurt.

21. Feeling that people are unfriendly or dislike you.
22. Feeling inferior to others.
23. Nausea or upset stomach.
24. Feeling that you are watched or talked about by others.
25. Trouble falling asleep.
26. Having to check and double check what you do.
27. Difficulty in making decisions.
28. Feeling afraid to travel on buses, subways, or trains.
29. Trouble getting your breath.
30. Hot or cold spells.
31. Having to avoid certain things, places, or activities because they frighten you.
32. Your mind going blank.
33. Numbness or tingling in parts of your body.
34. The idea that you should be punished for your sins.
35. Feeling hopeless about the future.
36. Trouble concentrating.
37. Feeling weak in parts of your body.
38. Feeling tense or keyed up.
39. Thoughts of death or dying.
40. Having urges to beat, injure, or harm someone.
41. Having urges to break or smash things.
42. Feeling very self-conscious with others.
43. Feeling uneasy in crowds.
44. Never feeling close to another person.
45. Spells of terror or panic.
46. Getting into frequent arguments.

47. Feeling nervous when you are left alone.
48. Others not giving you proper credit for your achievements.
49. Feeling so restless you could not sit still.
50. Feelings of worthlessness.
51. Feeling that people will take advantage of you if you let them.
52. Feelings of guilt.
53. The idea that something is wrong with your mind.

Appendix C

Schizotypal Personality Questionnaire-Brief

- 2 strongly disagree
- 1 disagree
- 0 neutral
- 1 agree
- 2 Strongly disagree

1. People sometimes find me aloof and distant.
2. Have you ever had the sense that some person or force is around you, even though you cannot see anyone ?
3. People sometimes comment on my unusual mannerisms and habits.
4. Are you sometimes sure that other people can tell what you are thinking?
5. Have you ever noticed a common event or object that seemed to be a special sign for you?
6. Some people think that I am a very bizarre person.
7. I feel I have to be on my guard even with friends.
8. Some people find me a bit vague and elusive during a conversation.
9. Do you often pick up hidden threats or put-downs from what people say or do?
10. When shopping do you get the feeling that other people are taking notice of you?
11. I feel very uncomfortable in social situations involving unfamiliar people.
12. Have you had experiences with astrology, seeing the future, UFOs, ESP or a sixth sense?
13. I sometimes use words in unusual ways.
14. Have you found that it is best not to let other people know too much about you?
15. I tend to keep in the background on social occasions.
16. Do you ever suddenly feel distracted by distant sounds that you are not normally aware of?
17. Do you often have to keep an eye out to stop people from taking advantage of you?
18. Do you feel that you are unable to get "close" to people?
19. I am an odd, unusual person.
20. I find it hard to communicate clearly what I want to say to people.
21. I feel very uneasy talking to people I do not know well.
22. I tend to keep my feelings to myself.

Appendix D

Emotional Stroop Stimuli

Positive Words

WORD	VALENCE	AROUSAL	LENGTH	HAL FREQUENCY	HAL FREQUENCY LOG	ORTHOGRAPHIC NEIGHBORHOOD	SYLLABLES
clouds	6.18	3.3	6	4193	8.34	1	1
cottage	6.45	3.39	7	1318	7.18	0	2
nectar	6.9	3.89	6	512	6.24	0	2
relaxed	7	2.39	7	4399	8.39	3	2
comfort	7.07	3.93	7	6490	8.78	1	2
song	7.1	6.07	4	59801	11	9	1
bless	7.19	4.05	5	3927	8.28	2	1
sleep	7.2	2.8	5	25606	10.15	6	1
bunny	7.24	4.06	5	5325	8.58	5	2
bird	7.27	3.17	4	19070	9.86	3	1
gentle	7.31	3.21	6	6694	8.81	1	2
cozy	7.39	3.32	4	726	6.59	3	2
warmth	7.41	3.73	6	2499	7.82	0	1
surprised	7.47	7.47	9	22369	10.02	1	2
bed	7.51	3.61	3	31345	10.35	13	1
wise	7.52	3.91	4	13444	9.51	10	1
secure	7.57	3.14	6	14198	9.56	0	2
intimate	7.61	6.98	8	3281	8.1	0	3
desire	7.69	7.35	6	23188	10.05	0	2
outstanding	7.75	6.24	11	9127	9.12	0	3
sunlight	7.76	6.1	8	2621	7.87	0	2
birthday	7.84	6.68	8	8557	9.05	0	2
pillow	7.92	2.97	6	2110	7.65	2	2
millionaire	8.03	6.14	11	1092	7	0	3
cheer	8.1	6.12	5	1904	7.55	3	1
joke	8.1	6.74	4	20262	9.92	7	1
terrific	8.16	6.23	8	3890	8.27	0	3
graduate	8.19	7.25	8	18640	9.83	0	2
victory	8.32	6.63	7	11304	9.33	0	3
mother	8.39	6.13	6	42113	10.65	1	2
joy	8.6	7.22	3	11703	9.37	10	1
miracle	8.6	7.65	7	5864	8.68	0	3

Negative Words

WORDS	VALENCE	AROUSAL	LENGTH	HAL FREQUENCY	HAL FREQUENCY LOG	ORTHOGRAPHIC NEIGHBORHOOD	SYLLABLES
cancer	1.5	6.42	6	18210	9.81	5	2
abuse	1.8	6.83	5	25915	10.16	2	2
gloom	1.88	3.83	5	3144	8.05	2	1
killer	1.89	7.86	6	13599	9.52	4	2
afraid	2	6.67	6	23303	10.06	0	2
despise	2.03	6.28	7	1416	7.26	1	2
hate	2.12	6.95	4	44130	10.69	16	1
fearful	2.25	6.33	7	1585	7.37	0	2
violent	2.29	6.89	7	12285	9.42	0	2
anger	2.34	7.63	5	8608	9.06	2	2
tumor	2.36	6.51	5	1525	7.33	4	2
rage	2.41	8.17	4	6289	8.75	13	1
jealousy	2.51	6.36	8	1497	7.31	0	3
destroy	2.64	6.83	7	17424	9.77	0	2
obesity	2.73	3.87	7	1029	6.94	0	4
coward	2.74	4.07	6	1659	7.41	2	1
pervert	2.79	6.26	7	1300	7.17	0	2
brutal	2.8	6.6	6	3220	8.08	0	2
bored	2.95	2.83	5	7024	8.86	5	1
trouble	3.03	6.85	7	49725	10.81	0	2
dreary	3.05	2.98	6	408	6.01	1	2
inferior	3.07	3.83	8	5490	8.61	1	3
messy	3.15	3.34	5	2444	7.8	2	2
handicap	3.29	3.81	8	2279	7.73	0	3
mucus	3.34	3.41	5	419	6.04	0	2
pity	3.37	3.72	4	4908	8.5	3	2
fault	3.43	4.07	5	19968	9.9	2	1
mold	3.55	4.07	4	3748	8.23	12	1
weary	3.79	3.81	5	1145	7.04	2	2
rusty	3.86	3.77	5	3203	8.07	5	2
meek	3.87	3.8	4	1498	7.31	6	1
slow	3.93	3.39	4	43719	10.69	13	1

Neutral Words

WORDS	VALENCE	AROUSAL	LENGTH	HAL FREQUENCY	HAL FREQUENCY LOG	ORTHOGRAPHIC NEIGHBORHOOD	SYLLABLES
cold	4.02	5.19	4	34854	10.46	12	1
excuse	4.05	4.48	6	19298	9.87	1	2
skull	4.27	4.75	5	7302	8.9	3	1
narcotic	4.29	4.93	8	554	6.32	0	3
cellar	4.32	4.39	6	1138	7.04	1	2
hide	4.32	5.28	4	14077	9.55	10	1
skeptical	4.52	4.91	9	4308	8.37	1	3
army	4.72	5.03	4	34024	10.43	2	2
razor	4.81	5.36	5	3264	8.09	0	2
hammer	4.88	4.58	6	6714	8.81	2	2
storm	4.95	5.71	5	19846	9.9	3	1
stove	4.98	4.51	5	1846	7.52	7	1
swamp	5.14	4.86	5	5706	8.65	3	1
passage	5.28	4.36	7	8939	9.1	1	2
theory	5.3	4.62	6	48737	10.79	0	2
activate	5.46	4.86	8	3486	8.16	0	3
avenue	5.5	4.12	6	20151	9.91	1	3
boxer	5.51	5.12	5	1744	7.46	5	2
repentant	5.53	4.69	9	1307	7.18	0	3
rock	5.56	4.52	4	44285	10.7	12	1
mischief	5.57	5.76	8	830	6.72	0	2
runner	5.67	4.76	6	4480	8.41	1	2
frog	5.71	4.54	4	3126	8.05	2	1
trumpet	5.75	4.97	7	7157	8.88	1	2
mushroom	5.78	4.72	8	1873	7.54	0	2
whistle	5.81	4.69	7	2672	7.89	2	2
custom	5.85	4.66	6	18290	9.81	0	2
hawk	5.88	4.39	4	3597	8.19	4	1
highway	5.92	5.16	7	11286	9.33	0	2
salute	5.92	5.31	6	1321	7.19	0	2
invest	5.93	5.12	6	7965	8.98	5	2
sentiment	5.98	4.41	9	2623	7.87	0	3

Descriptive Statistics
Mean (Standard Deviation)

WORD SET	VALENCE	AROUSAL	LENGTH	HAL FREQUENCY	HAL FREQUENCY LOG	ORTHOGRAPHIC NEIGHBORHOOD	SYLLABLES
POSITIVE	7.59 (0.57)	5.06 (1.73)	6.25 (2)	12,111.63 (13,331.81)	8.81 (1.2)	2.53 (3.61)	1.84 (0.72)
NEGATIVE	2.77 (0.67)	5.25 (1.68)	5.72 (1.28)	10,378.63 (13,631.43)	8.43 (1.35)	3.22 (4.36)	1.88 (0.71)
NEUTRAL	5.22 (0.63)	4.84 (0.39)	6.1 (1.57)	10,837.50 (12,979.18)	8.63 (1.21)	2.47 (3.4)	1.91 (0.69)

Appendix E

PANAS-X

This scale consists of a number of words and phrases that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you have felt this way during the past few weeks. Use the following scale to record your answers:

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely
_____ cheerful	_____ sad	_____ active	_____ angry at self	
_____ disgusted	_____ calm	_____ guilty	_____ enthusiastic	
_____ attentive	_____ afraid	_____ joyful	_____ downhearted	
_____ bashful	_____ tired	_____ nervous	_____ sheepish	
_____ sluggish	_____ amazed	_____ lonely	_____ distressed	
_____ daring	_____ shaky	_____ sleepy	_____ blameworthy	
_____ surprised	_____ happy	_____ excited	_____ determined	
_____ strong	_____ timid	_____ hostile	_____ frightened	
_____ scornful	_____ alone	_____ proud	_____ astonished	
_____ relaxed	_____ alert	_____ jittery	_____ interested	
_____ irritable	_____ upset	_____ lively	_____ loathing	
_____ delighted	_____ angry	_____ ashamed	_____ confident	
_____ inspired	_____ bold	_____ at ease	_____ energetic	
_____ fearless	_____ blue	_____ scared	_____ concentrating	
_____ disgusted with self	_____ shy	_____ drowsy	_____ dissatisfied with self	

Vita

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