

Positive and negative schizotypy in a student sample: neurocognitive and clinical correlates

Wayne M. Dinn^{a,*}, Catherine L. Harris^a, Ayse Aycicegi^{b,1}, Paul Greene^a,
Margaret S. Andover^a

^a*Department of Psychology, Boston University, Boston, MA, USA*

^b*Istanbul University, Istanbul, Turkey*

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Abstract

Positive and negative schizotypy may represent discrete factors or dimensions. To determine if distinct neurocognitive profiles are associated with these dimensions or factors, we classified university students on the basis of positive and negative schizotypal symptoms and conducted separate analyses. Following prior work in the neuropsychiatric literature, we predicted that subtle prefrontal deficits would be selectively associated with negative schizotypy and associated clinical states or personality dimensions including antisocial personality disorder, obsessive–compulsive personality traits, generalized and social anxiety, empathy, and impulsivity. Classification of subjects into positive and negative schizotypy groups revealed distinct neurocognitive and clinical profiles. We observed a positive relation between measures of temporolimbic dysfunction, impulsivity, antisocial behavior, and positive schizotypal phenomena. Negative schizotypy was associated with subtle performance deficits on measures of frontal executive function, increased social anxiety, and obsessive–compulsive phenomena. Findings are consistent with the contention that positive and negative schizotypy represent discrete factors. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

Schizotypal personality disorder (SPD) has been conceptualized as an attenuated form or phenotypic variant of schizophrenia. Diagnostic criteria for SPD include ideas of reference, magical ideation, unusual perceptual experiences, odd thinking and speech, suspiciousness, inappropriate or constricted affect,

eccentric behavior, lack of close friends, and excessive social anxiety (American Psychiatric Association, 1994).

Subtle prefrontal deficits are associated with schizotypal personality. Individuals receiving a SPD diagnosis demonstrate a greater degree of impairment on tests assessing frontal executive function including the Wisconsin Card Sorting Test (Diforio et al., 2000; Trestman et al., 1995; Voglmaier et al., 1997), California Verbal Learning Test (Bergman et al., 1998; Voglmaier et al., 1997), and the Trail-Making Test (Trestman et al., 1995). Schizotypic subjects also exhibit performance deficits on visuospatial working

* Corresponding author. Address: 42 Washington Terrace, Whitman, MA 02382, USA. Tel.: +1-781-447-6058.

E-mail address: dinn@bu.edu (W.M. Dinn).

¹ Visiting Scholar — Boston University.

memory tasks (Farmer et al., 2000; Park and McTiague, 1997; Roitman et al., 2000). Moreover, schizotypic subjects manifest volumetric abnormalities (i.e. volume reduction) in temporal and prefrontal regions (Dickey et al., 1999; Buchsbaum et al., 1997; Raine et al., 1992a).

University students psychometrically defined as schizotypic or 'psychosis-prone' also exhibit performance deficits on tasks assessing frontal executive function including the Wisconsin Card Sorting Test (Lenzenweger and Korfine, 1994; Lyons et al., 1991; Poreh et al., 1995; Suhr, 1997), Trail-Making Test (Poreh et al., 1995), and the Booklet Category Test (Poreh et al., 1995).

1.1. *Conflicting findings*

Schizotypy is not invariably associated with impaired performance on tasks assessing frontal executive function. Lenzenweger and Gold (2000) found that students psychometrically identified as schizotypic did not demonstrate performance deficits on verbal and auditory working memory tasks in comparison to controls. How can we account for these conflicting results?

One possibility is that students psychometrically defined as schizotypic present with a less severe form of schizotypal personality relative to subjects diagnosed with SPD. However, several studies found that subjects diagnosed with SPD did *not* demonstrate performance deficits on tests assessing frontal executive functioning (i.e. the WCST) (Raine et al., 1992b; Condray and Steinhauer, 1992).

A second possibility is that neurocognitive deficits are selectively associated with negative, rather than positive, symptoms. A discussion of the two-factor model (or two-syndrome construct) of schizotypy may clarify this issue. A two-factor model of schizotypy is based on Crow's two-syndrome concept of schizophrenia (i.e. Type I — positive symptoms and Type II — negative symptoms) (Crow, 1980, 1985). Variations in dopaminergic activity are associated with both positive and negative schizotypy (Siever, 1995). *Hypodopaminergia* in prefrontal cortex is associated with negative symptoms such as affective flattening, avolition and apathy, asociality, and cognitive impairment. *Hyperdopaminergia* in subcortical mesolimbic structures may generate positive schizotypal

symptoms including magical ideation, ideas of reference, and unusual perceptual experiences. Several researchers suggest that positive and negative schizotypy represent distinct factors or dimensions. Siever (1995) noted that these dimensions or factors are independently heritable and speculated that distinct pathologies underlie each dimension.

To determine if distinct neurocognitive profiles are associated with these factors, we classified subjects on the basis of positive and negative schizotypal symptoms and conducted separate analyses of neurocognitive test performance.

Negative schizotypy may be selectively associated with executive dysfunction. Diforio et al. (2000) reported that adolescents with SPD demonstrated performance deficits on the modified WCST. Moreover, impaired performance on the WCST was associated with negative, rather than positive, symptoms. As noted previously, Lenzenweger and Gold (2000) found that students psychometrically identified as schizotypic did not exhibit performance deficits on working memory tasks relative to controls. It is important to note that Lenzenweger and Gold employed the Perceptual Aberration Scale to classify subjects. The Perceptual Aberration Scale taps positive schizotypal symptoms (e.g. perceptual distortions). However, Lyons et al. (1991) recruited schizotypal subjects via newspaper advertisements which highlighted positive symptoms (i.e. advertisements seeking individuals who had experienced paranormal phenomena such as ESP and telepathy) and found that individuals with positive symptom schizotypy demonstrated performance decrements on the WCST relative to control subjects.

The present study uses a student sample to investigate whether subtle prefrontal deficits are selectively associated with negative schizotypal personality features. Following prior work in the neuropsychiatric literature, we predicted that negative schizotypy would be associated with impaired performance on tests assessing frontal executive function.

1.2. *Patterns of comorbidity*

We also investigated the relationship between positive/negative schizotypy and associated clinical states or personality dimensions including antisocial personality disorder (APD), obsessive–compulsive

personality traits, generalized and social anxiety, empathy, and impulsivity. In prior work, we observed an association between schizotypal personality features, obsessive–compulsive personality traits, and excessive social anxiety. Are these clinical states selectively associated with positive or negative schizotypy?

1.2.1. Antisocial personality, impulsivity, empathy, and schizotypy

Meehl (1989) suggested that a significant subset of psychopathic subjects are schizotaxic. Siever et al. (1990) found that approximately 20% of SPD patients also met diagnostic criteria for APD. We predicted that individuals psychometrically defined as schizotypic would achieve significantly higher scores on a measure of antisocial personality relative to comparison subjects. Although schizotypy may be associated with antisocial personality, it has not been determined whether antisocial behavior is selectively associated with positive or negative schizotypal personality features and we make no a priori predictions.

In prior unpublished work, we observed an association between measures of impulsivity, empathy, and schizotypal personality. We found that subjects psychometrically defined as schizotypic obtained significantly higher scores on measures of impulsivity and significantly lower scores on measures of empathy relative to matched controls. In the present study, we included self-report measures of impulsivity and empathy.

1.2.2. Obsessive–compulsive personality and schizotypy

In prior work, we observed an association between schizotypal personality features and obsessive–compulsive personality traits (OCPTs). Moreover, both OCPTs and schizotypal personality features were associated with performance deficits on tests assessing frontal executive function (Aycicegi et al., 2001; Dinn et al., 2001a,b). We suggested that the preoccupation with rules and organization, perfectionism, and inflexibility displayed by subjects exhibiting OCPTs may represent behavioral strategies which evolve in response to executive function deficits.

Why would OCPD and schizotypal personality covary? As noted previously, negative symptoms are associated with cognitive deficits (i.e. performance

deficits on tests of frontal executive functioning). OCPTs may represent adaptive or compensatory strategies which develop in response to executive function deficits. That is, OC symptoms may represent adaptations to subtle prefrontal deficits associated with negative schizotypy. In the present study, we predict that students obtaining high scores on a measure of negative schizotypal symptoms will also achieve clinically significant scores on a measure of obsessive–compulsive personality.

However, in prior work, we also observed a strong relation between social anxiety and obsessive–compulsive phenomena. Thus, OC symptoms, such as compulsive rituals and checking behaviors, may represent compensatory mechanisms for reducing anxiety. Given that both OCD and SPD are associated with social anxiety, it is important to understand the relation between schizotypy and anxiety states, and separately examine social vs. generalized anxiety. Indeed, excessive social anxiety is a characteristic clinical feature of SPD (American Psychiatric Association, 1994).

1.3. Research goals

Our principal research objectives were:

1. an exploration of the relationship between positive and negative schizotypy, and neuropsychological test performance in a student sample;
2. an investigation of the relation between schizotypy and associated clinical states or personality dimensions including antisocial behavior, obsessive–compulsive phenomena, generalized and social anxiety, empathy, and impulsivity.

2. Method

2.1. Subjects

One hundred and three undergraduate students served as participants for this study. Participants were drawn from introductory psychology courses and received course credit.

The sample comprised 75 female and 28 male students. Female participants had a mean age of 18.6 years ($SD = 1.0$) and had completed 13.4 years

Table 1
Positive Schizotypy: Clinical and Neurocognitive Test Findings: mean (SD)
High-, median-, and low-positive schizotypy

	High	Median	Low	<i>F</i> (2, 100)	<i>p</i>	<i>f</i> ^a
<i>n</i>	17	60	26			
Age	18.5 (0.9)	18.9 (1.3)	19.1 (1.3)	1.09	0.338	–
Education	13.4 (0.9)	13.6 (0.9)	13.7 (1.1)	0.50	0.602	–
Gender (Female/Male)	11/6	47/13	17/9			
Handedness (Right/Left)	17/0	55/5	21/5			
Positive Symptoms	6.3 (0.4)	3.9 (0.8)	1.3 (0.7)	231.33	0.0001	
Negative Symptoms	3.7 (2.0)	3.0 (2.3)	2.8 (2.1)	0.77	0.464	–
Limbic System Checklist-33						
LSCL-Total	38.9 (15.9)	25.0 (11.5)	18.1 (11.3)	14.77	0.0001	0.54
Somatic	10.8 (5.5)	9.3 (3.9)	7.8 (4.8)	2.30	0.104	0.21
Hallucinatory	9.3 (6.1)	5.9 (4.2)	3.1 (2.8)	10.35	0.0001	0.45
Automatisms	9.0 (5.2)	4.7 (3.5)	3.7 (3.0)	11.08	0.0001	0.47
Dissociative	9.7 (3.9)	5.1 (3.1)	3.3 (2.7)	21.24	0.0001	0.65
I 7 Questionnaire						
Empathy	15.9 (2.2)	14.9 (2.6)	13.2 (3.2)	5.32	0.007	0.32
Venturesomeness	9.4 (3.6)	9.1 (3.1)	7.8 (3.6)	1.58	0.210	0.17
Impulsivity	9.0 (3.9)	7.4 (3.8)	3.9 (3.2)	11.61	0.0001	0.48
Fear Survey Subscales						
Social Anxiety	16.7 (7.5)	17.6 (5.7)	16.3 (6.0)	0.49	0.611	–
Specific Phobia	23.1 (8.2)	21.9 (8.9)	22.6 (7.9)	0.15	0.855	–
Personality Diagnostic Questionnaire (PDQ-4)						
OCPD	4.4 (1.5)	3.8 (1.3)	3.2 (1.1)	4.04	0.0204	0.28
APD	2.3 (0.9)	1.3 (1.2)	0.8 (1.0)	8.17	0.0005	0.40
FAS Test	40.1 (7.6)	35.9 (7.8)	37.6 (8.4)	1.95	0.147	–
Divergent Thinking Task	6.0 (2.4)	6.2 (2.1)	6.8 (4.4)	0.43	0.648	–
Porteus Maze Task	37.7s (20.8)	37.9 (21.6)	39.2s (23.0)	0.03	0.963	–
Trail-Making Test						
Trail-Making (A)	28.3s (7.0)	29.7s (8.7)	31.0s (11.8)	0.44	0.642	–
Trail-Making (B)	50.2s (9.3)	50.0s (13.5)	52.4s (12.8)	0.31	0.728	–
Stroop Color–Word Test						
StroopWord-c	464.1ms (64)	513.7ms (103)	532.2ms (76)	2.93	0.057	0.24
StroopWord-i	474.9ms (75)	517.0ms (102)	543.1ms (93)	2.57	0.080	0.22
StroopColor-c	660.1ms (94)	694.4ms (98)	683.4ms (114)	0.75	0.472	–
StroopColor-i	785.2ms (114)	777.5ms (112)	782.0ms (122)	0.03	0.965	–
Rey–Osterrieth Complex Figure Test						
Copy Organization	4.7 (1.5)	4.2 (1.8)	4.6 (1.6)	0.70	0.494	–
Recall Accuracy	21.7 (5.7)	22.7 (5.3)	24.6 (4.8)	1.86	0.159	0.19
Frontal Lobe Personality Scale-PV						
Disinhibition	34.8 (5.0)	31.5 (5.8)	27.2 (5.7)	9.84	0.0001	0.44
Exec. Dysfunction	40.5 (7.4)	38.3 (7.5)	35.0 (6.8)	3.19	0.0450	0.25
Apathy	25.8 (6.6)	25.6 (5.5)	24.2 (6.0)	0.56	0.568	–

^a *f*^e = Effect Size (Cohen's *f*).

Note. Personality Diagnostic Questionnaire (PDQ-4)-OCPD = Obsessive–compulsive Personality Disorder Subscale; APD = Antisocial Personality Disorder Subscale; Stroop Color–Word Test (blocks 1 and 2 = word naming, blocks 3 and 4 = color naming), c = congruent, i = incongruent; FAS Test = Controlled Word Fluency Test.

of education ($SD = 0.7$). Sixty-seven female subjects were right-handed and eight were left-handed, as determined by self-report. Mean age of male participants was 19.6 years ($SD = 1.7$) and their mean educational level was 14.1 years ($SD = 1.1$). Twenty-six male subjects were right-handed and two were left-handed, as determined by self-report. Written informed consent was obtained from all participants. Demographic data are presented in Tables 1 and 2.

2.2. Procedure

We administered a neuropsychological test battery consisting of measures sensitive to prefrontal dysfunction, and a battery of personality questionnaires and clinical scales. The neurocognitive test battery consisted of a computer version of the Stroop Color–Word Test, Controlled Word Fluency Test (FAS Test) (Goodglass and Kaplan, 1972), Porteus Maze Task (Porteus, 1955), Trail-Making Test (Parts A and B) (Reitan and Wolfson, 1985), Divergent Thinking Task (based on Guilford and Hoepfner, 1971), and the Rey Complex Figure Test (Lezak, 1995). Personality questionnaires and clinical scales included: the I 7 Questionnaire (Eysenck et al., 1985), the Frontal Lobe Personality Scale (FLPS-Patient Version) (Grace and Malloy, 1992), the Schizotypal Personality Questionnaire-B (SPQ-B) (Raine and Benishay, 1995), Limbic System Checklist-33 (LSCL-33) (Teicher et al., 1993), the Personality Diagnostic Questionnaire (PDQ-4) (Hyler, 1994), and a modified version of the Fear Survey Schedule (Wolpe and Lang, 1964).

All computerized tasks were administered on a Macintosh IIfx. Reaction time and voice onset latencies were collected using a millisecond timer that interfaces with PsyScope; experimental design software developed by Cohen et al. (1993). Neurocognitive tests were administered by trained research technicians who followed a standardized testing protocol. Technicians were blind to the group status of participants (i.e. SPQ-B scores). Personality questionnaires and clinical scales were administered and scored by computer.

2.3. Prefrontal measures

2.3.1. Stroop Color–Word Test

We developed a computer version of the Stroop

Color–Word Test. Participants were instructed to read words describing colors as rapidly as possible. Words were displayed one at a time on the computer monitor, with the ink color being either consistent or inconsistent with the given word. During the first block (non-conflict block) the subject was asked to read the word displayed on the monitor and ignore the ink color (40 trials). During the second block (conflict block) the participant was asked to identify the ink color (40 trials). Response latencies were recorded using a voice-activated millisecond timer. The dependent measure was response time.

2.3.2. Porteus maze task (Porteus, 1955)

Participants were required to find the exit route from a relatively complex maze. Efficient performance requires planning and anticipation of blocked routes. Time to completion was the dependent measure.

2.3.3. Word Fluency Test (FAS test) (Goodglass and Kaplan, 1972)

During the Word Fluency Test (FAS Test) the subject was asked to write down as many words as possible that begin with a specific letter (F, A, or S) during three one-minute trials. Total number of words produced was the dependent measure.

2.3.4. Divergent Thinking Task (based on Guilford and Hoepfner, 1971)

During this task subjects were asked to name as many different uses of a newspaper as possible during a one-minute trial. They were provided with the following example: one use is rolling up the newspaper to swat a mosquito. Number of alternate uses was the dependent measure.

2.3.5. Trail-Making Test (Parts A and B) (Reitan and Wolfson, 1985)

During Part A of the Trail-Making Test subjects were instructed to connect 25 numbered circles (1–25) randomly distributed over an 8×11 sheet of paper. Subjects were instructed to connect circles as rapidly as possible. During Part B subjects were required to connect 25 circles which contain numbers (1–13) or letters (A–L) and must sequentially alternate between numbers and letters (that is, 1–A–2–B–3–C, and so forth). Subjects received feedback when

Table 2
 Negative Schizotypy: Clinical and Neurocognitive Test Findings: mean (SD)
 High-, median-, and low-positive schizotypy

	High	Median	Low	<i>F</i> (2, 100)	<i>p</i>	<i>f</i> ^a
<i>n</i>	17	57	29			
Age	19.1 (1.5)	18.8 (1.3)	18.9 (1.2)	0.37	0.688	–
Education	13.7 (0.9)	13.5 (0.9)	13.6 (1.0)	0.09	0.908	–
Gender (Female/Male)	12/5	39/18	24/5			
Handedness (Right/Left)	16/1	50/7	27/2			
Positive Symptoms	4.1 (1.5)	3.7 (1.9)	3.5 (1.6)	0.61	0.542	–
Negative Symptoms	6.5 (0.6)	3.4 (1.1)	0.5 (0.5)	222.62	0.0001	
Limbic System Checklist-33						
LSCL-Total	26.8 (13.9)	26.5 (15.2)	23.1 (10.7)	0.66	0.516	–
Somatic	9.2 (6.0)	9.4 (4.3)	8.6 (4.0)	0.27	0.760	–
Hallucinatory	5.4 (3.5)	6.1 (5.4)	5.5 (3.9)	0.22	0.801	–
Automatisms	5.7 (4.2)	5.4 (4.4)	4.3 (3.2)	0.84	0.432	–
Dissociative	6.5 (3.7)	5.5 (4.2)	4.6 (2.6)	1.42	0.246	–
I 7 Questionnaire						
Empathy	14.7 (2.5)	14.5 (3.0)	14.9 (2.7)	0.20	0.814	–
Venturesomeness	8.3 (3.1)	8.9 (3.6)	9.1 (3.1)	0.28	0.750	–
Impulsivity	6.3 (4.2)	6.8 (3.9)	6.9 (4.3)	0.12	0.881	–
Fear Survey Subscales						
Social Anxiety	22.0 (4.6)	16.5 (6.2)	15.4 (5.3)	7.42	0.001	0.38
Specific Phobia	24.3 (7.5)	20.6 (8.6)	24.4 (8.2)	2.65	0.075	–
Personality Diagnostic Questionnaire (PDQ-4)						
OCPD	4.5 (1.4)	3.6 (1.2)	3.7 (1.5)	3.01	0.05	0.24
APD	1.2 (1.3)	1.4 (1.2)	1.2 (1.1)	0.46	0.631	–
FAS Test	34.7 (9.4)	37.7 (7.5)	37.1 (8.0)	0.91	0.404	0.13
Divergent Thinking Task	5.5 (2.8)	6.0 (2.1)	7.6 (3.8)	4.12	0.02	0.28
Porteus Maze Task	41.7s (19.1)	34.3s (17.4)	43.9s (28.6)	2.21	0.114	–
Trail-Making Test						
Trail-Making (A)	31.4s (9.8)	31.1s (9.5)	26.2s (7.6)	3.19	0.05	0.25
Trail-Making (B)	52.8s (9.9)	52.7s (13.6)	45.5s (11.1)	3.51	0.04	0.26
Stroop Color–Word Test						
StroopWord-c	534.1ms (105)	503.9ms (89)	508.5ms (95)	0.68	0.507	–
StroopWord-i	552.4ms (118)	506.8ms (85)	514.9ms (105)	1.44	0.241	–
StroopColor-c	696.1ms (94)	672.4ms (107)	706.6ms (93)	1.18	0.310	–
StroopColor-i	778.2ms (104)	779.0ms (117)	782.8ms (118)	0.01	0.986	–
Rey–Osterrieth Complex Figure Test						
Copy Organization	3.7 (1.8)	4.6 (1.6)	4.4 (1.7)	2.05	0.134	0.20
Recall Accuracy	22.1 (6.3)	23.0 (5.8)	23.4 (3.3)	0.33	0.715	–
Frontal Lobe Personality Scale–PV						
Disinhibition	32.0 (5.8)	30.4 (6.3)	31.5 (5.9)	0.60	0.549	–
Exec. Dysfunction	42.7 (8.7)	36.7 (6.3)	37.3 (8.0)	4.63	0.0110	0.30
Apathy	32.0 (4.1)	24.6 (5.3)	22.7 (4.7)	19.59	0.0001	0.62

^a *f*^a = Effect size (Cohen's *f*).

Note. Personality Diagnostic Questionnaire (PDQ-4)-OCPD = Obsessive–compulsive Personality Disorder Subscale; APD = Antisocial Personality Disorder Subscale; Stroop Color–Word Test (blocks 1 and 2 = word naming, blocks 3 and 4 = color naming), c = congruent, i = incongruent; FAS Test = Controlled Word Fluency Test.

circles were connected out of order. Time to completion was the dependent measure.

2.3.6. Rey–Osterrieth Complex Figure Test (ROCT) (Lezak, 1995)

Participants copied a complex geometric figure consisting of 18 separate elements. Subjects were required to reproduce the figure from memory after a 1-minute delay. We employed the 36-point itemized scoring system described by Lezak (1995) to evaluate constructional accuracy. We also used the test procedure and scoring approach described by Savage and colleagues (Savage et al., 1999) to assess constructional organization during the copy condition (6-point scoring system).

2.4. Clinical scales and personality questionnaires

2.4.1. Schizotypal Personality Questionnaire-B (SPQ-B) (Raine and Benishay, 1995)

The SPQ-B is a 22-item, forced-choice questionnaire. Scores range from 0 to 22. The SPQ-B is a brief, self-report screening instrument used to evaluate respondents for the presence of schizotypal personality features. A total score and three subscale scores were obtained.

The SPQ-B yields three subscale scores reflecting:

1. cognitive or perceptual distortions (e.g. “Have you ever had the sense that some person or force is around you, even though you cannot see anyone?”);
2. interpersonal difficulties (e.g. “Do you feel that you are unable to get ‘close’ to people?”); and
3. disorganization (e.g. “I sometimes use words in unusual ways.”) (Raine and Benishay, 1995, p. 351).

Items correspond to DSM-IV diagnostic criteria for SPD. The SPQ-B is a psychometrically sound instrument which compares favorably to established measures.

2.4.2. Frontal Lobe Personality Scale (FLPS-patient version) (Grace and Malloy, 1992)

Respondents were instructed to indicate how frequently they experience symptoms or exhibit behaviors associated with frontal lobe syndromes

including: (1) behavioral disinhibition; (2) executive function deficits; and (3) apathy, reflecting orbitofrontal, dorsolateral–prefrontal, and mesial–prefrontal/ anterior cingulate dysfunction, respectively.

2.4.3. Personality Diagnostic Questionnaire (PDQ-4) (Hyler, 1994)

The PDQ-4 is a true–false, self-report instrument. Items reflect DSM-IV diagnostic criteria for personality disorders. Questions were adapted from DSM-IV diagnostic criteria. The APD and OCPD Subscales were administered to participants.

2.4.4. Fear Survey Schedule-Modified Version (FSS-MV) (based on Wolpe and Lang, 1964)

We administered a modified version of the Fear Survey Schedule. The FSS-MV is a self-report index of anxiety and avoidance behavior. Participants were asked to indicate the degree of anxiety and avoidance behavior associated with specific social situations or when exposed to specific stimuli. The FSS-MV yields a total score and two subscale scores. During our modified version of the Fear Survey participants were instructed to indicate the degree of avoidance behavior associated with specific situations or stimuli presented on the computer screen because of fear or anxiety. Stimuli were classified in the following manner: (1) social situations; and (2) specific phobic situations.

2.4.5. I-7 Questionnaire (Eysenck et al., 1985)

The I 7 Questionnaire is a forced-choice instrument. Respondents were asked to indicate whether they agree or disagree with a series of statements related to three personality dimensions (impulsiveness, venturesomeness, and empathy).

2.4.6. Limbic System Checklist-33 (LSCL-33) (Teicher et al., 1993)

The Limbic System Checklist is a 33-item symptom inventory. Respondents were instructed to indicate how frequently they experience symptoms associated with temporolimbic dysfunction including ‘paroxysmal somatic disturbances, brief hallucinatory events, visual disturbances, automatisms, and dissociative disturbances’ (Teicher et al., 1993, p. 302).

2.5. Do neuropsychological tests possess localizing value?

Converging lines of evidence including functional neuroimaging research and human lesion studies suggest that the tasks employed in our protocol are sensitive measures of prefrontal dysfunction. Of course, we must proceed cautiously when we argue that variations in brain function correspond to patterns of neuropsychological impairment and clinical presentation. Nevertheless, several lines of evidence suggest that many of the experimental tasks employed in this study possess localizing value. Researchers have come to appreciate that the prefrontal region is not a unitary structure; rather, it is fractionable into anatomically and functionally distinct subsystems. Converging lines of evidence suggests that dorsolateral–prefrontal cortex mediates executive functions (Fletcher et al., 1998; Smith and Jonides, 1999), while orbitofrontal cortex modulates sensitivity to reinforcement contingencies (Rolls, 1995) and plays a major role in behavioral inhibition. Performance deficits on tests assessing executive functions may reflect dorsolateral– or mesial–prefrontal dysfunction. Impaired performance on verbal fluency and divergent thinking tasks may reflect dorsolateral–prefrontal dysfunction. Functional neuroimaging studies revealed significant flow augmentation and increased activity in dorsolateral–prefrontal cortex during verbal fluency tasks (Cantor-Graae et al., 1993; Warkentin et al., 1991) and classical tests of frontal executive function. An extensive body of evidence suggests that DLPF cortex mediates executive functions (e.g. planning, organization, and keeping in mind diverse future consequences) (Fletcher et al., 1998; Smith and Jonides, 1999). Moreover, patients with damage to the dorsolateral aspect of the prefrontal region display performance deficits on the classical tests of frontal executive functioning (e.g. the WCST). Efficient performance on the Trail-Making Test (Part B), Porteus Maze, and on the Rey–Osterrieth Complex Figure Test requires the use of organizational strategies. For example, efficient performance on the Porteus Maze Task requires planning and anticipation of blocked routes.

Difficulty inhibiting a prepotent response during the Stroop task may indicate ventral/orbitofrontal dysfunction. Subjects undergoing PET while partici-

pating in the Stroop Color–Word Test demonstrated right orbitofrontal activation as well as increased activity in bilateral parietal structures (Bench et al., 1993). During a second experiment, Bench et al. (1993) documented right frontal polar and right anterior cingulate activation during Stroop task performance. Efficient performance on the Stroop task requires sustained attention and impulse control. Therefore, the Stroop Color–Word Test should be considered a broadly frontal task. Nevertheless, orbitofrontal or ventral prefrontal systems may be implicated when presenting symptoms include impaired performance on neurocognitive tasks which require the subject to suppress a prepotent response pattern.

In summary, the imaging and human lesion literature is broadly consistent with the notion that the prefrontal region is fractionable into anatomically and functionally distinct subsystems and that specific neurocognitive tasks may tap specific prefrontal subsystems. However, our findings must be interpreted with caution. It is important to bear in mind that neurocognitive tests are only *indirect* measures of neurophysiological function and the localizing value of such tasks is uncertain.

2.6. Data analysis plan

As noted previously, several researchers suggest that positive and negative schizotypy represent distinct factors or dimensions. To determine if distinct neurocognitive profiles are associated with these dimensions or factors, we classified subjects on the basis of positive and negative schizotypy symptoms and conducted separate analyses. Students were assigned to low-, median-, and high-positive schizotypy groups on the basis of scores on the Cognitive–Perceptual Subscale (Factor 1) from the SPQ-B. Students were assigned to low-, median-, and high-negative schizotypy groups on the basis of performance on the Interpersonal Subscale (Factor 2) from the SPQ-B, a measure of negative schizotypal symptoms. Separate one-way analyses of variance (ANOVAs) were performed with schizotypy group assignment serving as the independent variable. Following univariate analyses, we conducted post hoc comparisons of means. Since the groups were not equal in size, we used the Scheffe test.

Effect sizes were calculated to ascertain the

strength of group differences. Cohen (1988) suggested that an effect size of 0.10 represents a small effect, while an effect size of 0.25 represents a moderate effect. Cohen (1988) maintained that effect sizes of 0.40 or greater represent large effects. Effect sizes (Cohen's f) for significant differences and for group differences which approached, but did not achieve, statistical significance are presented in Tables 1–2. The Pearson product–moment correlation was used to determine the strength of association between variables.

3. Results

Subtyping schizotypy: positive and negative dimensions. Classification of subjects into positive and negative schizotypy groups revealed distinct neurocognitive and clinical profiles. Interestingly, there was *no* relationship between the positive and negative schizotypy dimensions in the student sample ($r = 0.11$, ns). Findings are consistent with the contention that positive and negative schizotypy represent discrete factors (Siever, 1995).

3.1. Positive schizotypy

We observed a positive relation between measures of temporolimbic dysfunction, impulsivity, antisocial behavior, and positive schizotypal phenomena.

3.1.1. Temporolimbic dysfunction

Group differences on the Limbic System Checklist (total score) ($F(2, 100) = 14.77$, $p < 0.0001$) and subscales assessing the frequency of brief hallucinatory events ($F(2, 100) = 10.35$, $p < 0.0001$), automatisms ($F(2, 100) = 11.08$, $p < 0.0001$), and dissociative disturbances ($F(2, 100) = 21.24$, $p < 0.0001$) were significant.

Post hoc comparisons revealed that the high-positive symptom group obtained significantly higher scores on the Limbic System Checklist (total) in comparison to the median- and low-positive symptom groups. Median- and low-positive schizotypy groups did not differ significantly on the Limbic System Checklist (total score); however, group differences were in the expected direction. The high-positive symptom group scored significantly higher on the Limbic System Checklist subscales assessing the

frequency of automatisms and dissociative disturbances in comparison to the median- and low-positive schizotypy groups. The high-positive symptom group also obtained significantly higher scores on the brief hallucinatory events subscale in comparison to the median-positive symptom group, while the median-schizotypy group scored significantly higher on these measures relative to the low-positive schizotypy group.

Positive schizotypy scores (SPQ-B Factor 1) were significantly associated scores on the Limbic System Checklist including total score ($r = 0.50$, $p < 0.01$) and LSCL subscales assessing the frequency of dissociative disturbances ($r = 0.47$, $p < 0.01$), automatisms ($r = 0.40$, $p < 0.01$), and brief hallucinatory events ($r = 0.45$, $p < 0.01$), and were marginally associated with performance on the subscale assessing the frequency of paroxysmal somatic disturbances ($r = 0.23$, $p < 0.02$).

3.1.2. Clinical/personality measures

Positive schizotypy groups also differed on self-report measures of impulsivity and empathy, with $F(2, 100) = 11.61$, $p < 0.0001$ and $F(2, 100) = 5.32$, $p < 0.007$, respectively. As shown in Table 1, post hoc analysis revealed that high-positive schizotypy subjects obtained significantly higher scores on the impulsivity and empathy subscales (I 7 Questionnaire) in comparison to the low-positive schizotypy group. Moreover, the median-positive symptom group also obtained significantly higher scores on the impulsivity and empathy subscales relative to low-positive schizotypy subjects. Positive schizotypy was significantly associated with impulsivity ($r = 0.42$, $p < 0.01$) and empathy ($r = 0.30$, $p < 0.01$) subscale scores.

Positive schizotypy subjects also obtained higher scores on a self-report measure of antisocial personality (PDQ-4) in comparison to median- and low-positive symptom groups, $F(2, 100) = 8.17$, $p < 0.0005$, while median- and low-positive schizotypy groups did not differ on the APD Subscale. Scores on the Cognitive–Perceptual Subscale of the SPQ-B were significantly correlated with performance on the APD Subscale ($r = 0.34$, $p < 0.01$). Unexpectedly, group differences on the OCPD Subscale were significant. Post hoc analysis revealed that high-positive symptom subjects obtained higher scores on the OCPD

Subscale relative to low-positive schizotypy subjects ($F(2, 100) = 4.04, p < 0.03$). Low-, median-, and high-positive symptom groups did not differ on measures of generalized and social anxiety ($ps > 0.60$). Groups did not differ on remaining clinical/personality measures and did not differ in age or educational level (all $ps > 0.20$). Low-, median-, and high-positive schizotypy groups did *not* differ on the Interpersonal subscale of the SPQ-B (i.e. a measure of *negative* schizotypy) ($p > 0.40$).

3.1.3. Prefrontal measures

Positive schizotypy was associated with increased scores on the Disinhibition Subscale of the Frontal Lobe Personality Scale ($r = 0.44, p < 0.01$). Group differences on the Disinhibition Subscale were significant, with $F(2, 100) = 9.84, p < 0.0001$. Post hoc analysis revealed that the high-positive symptom group obtained significantly higher scores on the Disinhibition Subscale in comparison to the median-positive symptom group, while the median-schizotypy group scored significantly higher on this measure relative to the low-positive schizotypy group. Low-, median-, and high-positive symptom groups did not differ on tests of frontal executive function including the Trail-Making Test — Parts A and B ($ps > 0.64$), Controlled Word Fluency Test ($p > 0.14$), Divergent Thinking Task ($p > 0.64$), Porteus Maze Task ($p > 0.96$), and the Rey Complex Figure Task ($ps > 0.15$). As shown in Table 1, low-, median-, and high-positive symptom groups did *not* differ on the Apathy Subscale of the Frontal Lobe Personality Scale ($p > 0.56$). Although group differences on the Executive Dysfunction Subscale were marginally significant, as determined by an omnibus F statistic ($F(2, 100) = 3.19, p < 0.045$), post hoc comparisons using the more conservative Scheffe test revealed that group differences were not significant. High-positive schizotypy subjects displayed faster mean reaction times during word-naming trials of the Stroop Color–Word Test. Group differences were marginally significant ($ps < 0.08$).

We observed a positive relation between measures of disinhibition, impulsivity, antisocial behavior, and positive schizotypal phenomena. Do intercorrelations between these variables and positive schizotypy reflect an association between the

Cognitive–Perceptual Subscale of the SPQ-B and scales tapping a common psychological construct? Of course, LSCL-33 subscales assessing the frequency of dissociative disturbances and brief hallucinatory events, and the Cognitive–Perceptual Subscale of the SPQ-B may tap the same underlying construct.

Does the observed relation between impulsivity, disinhibition, antisocial personality, and positive schizotypy also reflect an association between the Cognitive–Perceptual Subscale of the SPQ-B and scales tapping a similar construct? To address this issue, regression analyses were performed. Scores on self-report measures of impulsivity, antisocial personality, and disinhibition were used as independent predictor variables, and positive schizotypy score was used as the dependent variable. Multiple regression analysis showed that predictor variables made *unique* contributions. Scores on measures of impulsivity, antisocial personality, and disinhibition significantly predicted positive schizotypy scores ($r = 0.51, F = 11.542, df = 3, 99, p < 0.0001$) with each independent predictor adding significantly to the prediction. We regressed Disinhibition Subscale and APD Subscale scores on positive schizotypy scores ($r = 0.48, F = 15.296, df = 2, 100, p < 0.0001$) and found that the predictor variables made unique contributions, with $p < 0.001$ and $p < 0.03$, respectively. Bivariate regression analysis revealed that performance on the Disinhibition Subscale ($r = 0.44, df = 1, 101, F = 24.718, p < 0.0001$), impulsivity scale ($r = 0.43, F = 23.108, df = 1, 101, p < 0.0001$) and APD Subscale ($r = 0.37, F = 16.623, df = 1, 101, p < 0.0001$) predicted positive schizotypy scores. We regressed Disinhibition and APD Subscale scores, and Limbic System Checklist totals on positive schizotypy scores ($r = 0.58, df = 3, 99, F = 16.397, p < 0.0001$) and found that the predictor variables made independent contributions to the prediction of positive schizotypy scores, with $p < 0.05, p < 0.04$, and $p < 0.0001$, respectively. The observed relation between scores on self-report measures of disinhibition, antisocial personality, temporolimbic dysfunction, and positive schizotypy does not appear to reflect an association between the Cognitive–Perceptual Subscale of the SPQ-B and psychometric measures tapping a common psychological construct.

3.2. Negative schizotypy

We observed an association between subtle performance deficits on measures of frontal executive function, increased social anxiety, and negative schizotypal symptoms.

3.2.1. Clinical/personality measures

High-negative symptom subjects obtained clinically significant scores on the OCPD Subscale relative to comparison groups ($F(2, 100) = 3.01, p < 0.05$). Negative schizotypy was also associated with increased social anxiety ($r = 0.36, p < 0.01$). Group differences on the social anxiety subscale were significant, with $F(2, 100) = 7.420, p < 0.001$. Post hoc analysis revealed that the high-negative schizotypy group scored significantly higher on the social anxiety subscale in comparison to median- and low-schizotypy subjects.

Low-, median-, and high-negative schizotypy groups did *not* differ on the Cognitive–Perceptual subscale of the SPQ-B ($p > 0.54$). Low-, median-, and high-negative schizotypy groups did not differ on self-report measures of impulsivity, empathy, venturesomeness, and antisocial behavior (all $ps > 0.63$). Group differences on Limbic System Checklist subscales were also not significant (all $ps > 0.24$).

3.2.2. Prefrontal measures

The high-negative symptom group demonstrated subtle performance deficits on tests of executive function including the Trail-Making Test (Parts A and B) and Divergent Thinking Task (see Table 2). Group differences on the Trail-Making Test (Parts A and B) were significant, with $F(2, 100) = 3.19, p < 0.05$ and $F(2, 100) = 3.51, p < 0.04$, respectively. Post hoc comparisons revealed that the high- and median-negative symptom groups demonstrated greater mean reaction times during the Trail-Making Test (Parts A and B) relative to low-negative schizotypy subjects. Group differences on the Divergent Thinking Task were also significant, with $F(2, 100) = 4.12, p < 0.02$. Post hoc analysis revealed that high-negative schizotypy subjects generated fewer alternate uses relative to comparison subjects. On the Frontal Lobe Personality Scale, negative schizotypy was associated with increased scores

on the Executive Dysfunction ($r = 0.24, p < 0.02$) and Apathy Subscales ($r = 0.50, p < 0.01$). The high-negative schizotypy group scored significantly higher on these subscales in comparison to median- and low-schizotypy subjects, with $F(2, 100) = 4.63, p < 0.02$ and $F(2, 100) = 19.59, p < 0.0001$, respectively. Group differences on the Disinhibition Subscale were not significant ($p > 0.54$).

We included a self-report index of anxiety and avoidance behavior (i.e. the FSS-MV) in order to examine the relation between social and generalized anxiety, and schizotypy. We observed a linear correlation between social anxiety and negative schizotypy; therefore, it is possible that performance deficits on tests assessing frontal executive function may be associated with performance or test anxiety rather than negative schizotypy per se. For this reason, we conducted analyses of covariance (ANCOVA), with total Fear Survey score used as a covariate. The association between negative schizotypy and subtle performance deficits on the Trail-Making (Part B) and Divergent Thinking tasks remained significant controlling for the effect of anxiety, with $F(2, 99) = 3.76, p < 0.027$ and $F(2, 99) = 4.10, p < 0.019$, respectively.

The high-negative symptom group obtained lower Rey copy organization scores relative to median- and low-negative schizotypy subjects; however, this difference did not achieve statistical significance ($p < 0.14$). Low-, median-, and high-negative schizotypy groups did not differ on the recall component of the Rey–Osterrieth Complex Figure Test ($p > 0.70$) and on the Porteus Maze ($p < 0.12$), and Stroop Color–Word Test (all $ps > 0.24$).

4. Handedness and schizotypy

In prior work, researchers reported an association between mixed handedness and schizotypal personality features among nonclinical subjects and students psychometrically identified as schizotypic or ‘psychosis-prone’ (Kim et al., 1992; Chapman and Chapman, 1987). We compared the neurocognitive test performance of right- and left-handed students. Ninety-three subjects were right-handed and 10 subjects were left-handed, as determined by self-report. Neurocognitive and clinical profiles were remarkably similar. Groups

did not differ on the SPQ-B ($ps > 0.26$), LSCL ($ps > 0.06$), Fear Survey ($ps > 0.24$), APD Subscale ($p > 0.24$), OCPD Subscale ($p > 0.65$), Disinhibition Subscale ($p > 0.07$), and measures of empathy ($p > 0.35$), venturesomeness ($p > 0.54$), and impulsivity ($p > 0.19$). Groups also did not differ on the Stroop task ($ps > 0.63$), Trail-Making Test (Parts A and B) ($ps > 0.54$), Divergent Thinking Task ($p > 0.28$), Porteus Maze Task ($p > 0.10$), Controlled Word Fluency Test ($p > 0.91$), and the Rey–Osterrieth Complex Figure Test ($ps > 0.51$). Right-handed subjects obtained significantly higher scores on the Executive Dysfunction ($p < 0.02$) and Apathy ($p < 0.03$) subscales from the FLPS-PV. In summary, we found *no* evidence of an association between left-handedness and schizotypy.

5. Gender and schizotypy

Research examining neurocognitive function in schizophrenia reveals significant gender-based differences. Seidman et al. (1997) found that male schizophrenia patients demonstrated performance deficits on measures considered sensitive to orbitofrontal (i.e. an odour discrimination task) and dorsolateral–prefrontal (i.e. the WCST) dysfunction relative to female schizophrenia subjects; however, both male and female schizophrenia patients demonstrated substantial neuropsychological deficits in comparison to healthy control subjects. To address the issue of gender effects on neurocognitive test performance in a nonclinical student sample, we compared the neurocognitive and clinical profiles of male and female students.

Male and female students exhibited remarkably similar *within*-group performance patterns. That is, we observed a positive relation between measures of temporolimbic dysfunction, impulsivity, antisocial behavior, and positive schizotypal phenomena within the male and female samples. Similarly, we observed an association between performance deficits on measures of frontal executive function, increased social anxiety, and negative schizotypal symptoms within female and male groups. Strikingly similar performance patterns were observed when we examined male and female groups separately.

However, there were significant *between*-group

differences. Male students obtained significantly higher scores on the Executive Dysfunction ($p < 0.04$) and Apathy ($p < 0.02$) Subscales of the FLPS relative to female students. Male students scored significantly higher on the venturesomeness subscale ($p < 0.008$) and obtained significantly lower scores on the empathy subscale ($p < 0.0009$) relative to female students. Male students obtained higher scores on the Interpersonal Subscale (Factor 2) from the SPQ-B, a measure of negative schizotypal symptoms, relative to female subjects; however, group differences did not attain statistical significance. Group differences on the remaining clinical measures did not approach significance.

Male subjects generated fewer words (FAS Test) and alternate uses (Divergent Thinking Task) in comparison to female students; although, differences were not statistically significant. Male students demonstrated significant performance deficits during the Trail-Making Test (Part B) ($p < 0.006$) relative to female subjects. Group differences on the Rey–Osterrieth Complex Figure and Stroop Color–Word Test did not approach significance. It is important to emphasize that group differences which approached, but did not attain, statistical significance may reflect a lack of power. The sample comprised 75 female and 28 male students. This gender distribution reflects the gender ratio in the College of Arts and Sciences.

6. Discussion

Classification of subjects into positive and negative schizotypy groups revealed distinct neurocognitive and clinical profiles. There was no relationship between the positive and negative schizotypy dimensions. This finding is consistent with the proposal that positive and negative schizotypy represent discrete dimensions or factors. Of course, multiple comparisons increase the danger of Type I error and our findings should be interpreted with caution. Nevertheless, results form a meaningful pattern and are consistent with prior research which found an association between performance deficits on tests of frontal executive function and schizotypal personality.

6.1. Negative schizotypy

Negative schizotypy was associated with subtle

performance deficits on measures of frontal executive function, increased social anxiety, and obsessive–compulsive phenomena. Negative schizotypy was associated with increased scores on the Executive Dysfunction and Apathy Subscales of the Frontal Lobe Personality Scale. However, low-, median-, and high-negative schizotypy groups did *not* differ on measures of temporolimbic dysfunction, impulsivity, and antisocial behavior. Group differences on the Disinhibition Subscale were not significant.

The relation between schizotypy, obsessive–compulsive phenomena, and executive function deficits merits further study. We observed that the presence of schizotypal personality features was associated with obsessive–compulsive personality traits. The preoccupation with rules and organization, perfectionism, and inflexibility displayed by subjects exhibiting obsessive–compulsive personality traits and schizotypal personality features may represent behavioral strategies which evolve in response to executive function deficits. In the present study, positive schizotypy groups also differed on the OCPD Subscale. This finding is not consistent with the notion that OCPTs represent compensatory strategies which develop in response to executive function deficits. In a second study (unpublished findings), we sought to characterize, with greater precision, the relationship between schizotypy, mood, anxiety, and obsessive–compulsive phenomena in a student sample ($n = 109$). In this study, positive schizotypy groups did not differ on measures of inattention, apathy, executive dysfunction, obsessive–compulsive personality, and social anxiety. Positive schizotypy groups did not differ significantly on the OCPD Subscale ($p > 0.91$). This finding suggests OCPTs may be selectively associated with *negative* schizotypy and supports the contention that negative schizotypal symptoms are associated with subtle cognitive deficits, which, in turn, are associated with the development of adaptive or compensatory strategies which are collectively labeled OCPD.

In the unpublished study, negative schizotypy was strongly associated with elevated scores on measures of inattention, executive dysfunction, obsessive–compulsive phenomena, and social anxiety. Negative schizotypy groups differed significantly on the PDQ-4 Subscale assessing OCPD ($p < 0.006$). Negative schizotypy groups also differed significantly on scales

measuring the frequency of compulsive checking, doubting, hoarding, ordering, obsessive ideation, and washing. Interestingly, positive schizotypy groups differed significantly only on the subscales measuring the frequency of obsessive ideation and doubting.

6.2. Positive schizotypy

In the present study, positive schizotypy groups did not differ on tests of frontal executive function, and on measures of generalized and social anxiety; however, positive schizotypy was associated with increased scores on self-report measures of disinhibition, impulsivity, antisocial personality, and temporolimbic dysfunction. Do intercorrelations between these variables and positive schizotypy reflect an association between the Cognitive–Perceptual Subscale of the SPQ-B and scales tapping a common psychological construct? To address this issue, regression analyses were performed. Scores on self-report measures of impulsivity, antisocial personality, and disinhibition were used as independent predictor variables, and positive schizotypy score was used as the dependent variable. Multiple regression analyses showed that predictor variables made *unique* contributions. Scores on measures of impulsivity, antisocial personality, and disinhibition significantly predicted positive schizotypy scores with each independent predictor adding significantly to the prediction. It is tempting to conclude that the relation between these variables reflects a common neurophysiological process. Of course, we must proceed cautiously when we argue that variations in brain function correspond to patterns of clinical presentation. Nevertheless, it is interesting to note that orbitofrontal dysfunction is associated with syndromes of disinhibition including antisocial personality disorder. Recent neuroimaging studies and neuropsychological test findings support the contention that prefrontal dysfunction (particularly orbitofrontal) is associated with psychopathic personality traits and antisocial behavior (Raine et al., 1998, 2000; Dinn and Harris, 2000; Lapierre et al., 1995). Antisocial personality, disinhibition and impulsivity, and positive schizotypy may reflect, at least in part, prefrontal (particularly orbitofrontal) *hypofunction*. Of course, the present study does *not* directly test this hypothesis.

6.3. Conclusion

Our findings lend partial support to the suggestion that positive and negative schizotypy represent discrete neurobehavioral dimensions. Investigating brain–behavior relationships in a nonclinical sample (such as university students) may advance our understanding of the mechanisms that underlie schizophrenic phenomena. Establishing neurocognitive/clinical correlations in nonclinical samples relatively free of possible confounding variables such as lengthy psychoactive medication use, generalized intellectual deficits, knowledge of diagnostic status, and the effects of institutionalization, may shed light on the origins of these complex states.

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